THE UNIVERSITY OF ALBERTA

RELEASE FORM

NAME OF AUTHOR ..... FERN DARLENE SNART .....

TITLE OF THESIS ..... LEVELS OF PROCESSING AND MEMORY: A .....

..... DEVELOPMENTAL APPROACH .....

DEGREE FOR WHICH THESIS WAS PRESENTED ..... DOCTOR OF PHILOSOPHY .....

YEAR THIS DEGREE GRANTED ..... SPRING, 1979 .....

LEVELS OF PROCESSING AND MEMORY

A DEVELOPMENTAL APPROACH

by

© Fern Snart

A Thesis

Submitted to the Faculty of Graduate Studies and Research

in Partial Fulfilment of the Requirements for the Degree

of Doctor of Philosophy

In

Department of Educational Psychology

University of Alberta

Edmonton, Alberta

Spring, 1979

UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled "Levels of Processing and Memory: A Developmental Approach" submitted by Fern Darlene Snart in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

ABSTRACT

The effects of both depth of processing, as defined by Craik and Lockhart (1972), and simultaneous and successive processing, as described by Das and his colleagues (1975), are examined developmentally within the present study. The purpose of the investigation was to discover whether typical changes occur in information-processing and memory, with cognitive development and increased competence.

The effects of levels of processing were examined with three groups of 50 subjects; mean ages were 6.7, 11.4, and 16.9 years. Subjects within a group were randomly assigned to either an incidental or intentional learning condition. The results indicated that recall and recognition improved with increasing depth of processing, providing support for the basic tenets of levels theory. Both recall and recognition were found to improve with increases in chronological age, and this general finding was modified by findings that increased level of analysis, or intention to remember, could further accentuate memory performance in children, and that the magnitude of such effects varied for specific age groups. It became apparent that, in order to fully understand the effects of levels of analysis, there is a need for additional research into the interactional features of levels of processing and other contextual variables affecting memory.

Subjects were also given marker tests for both simultaneous and successive processing. Factor loadings for each age group were similar to those found in past research, lending further support to the information-integration model. When the recall scores for levels

of analysis were included within a factor analysis of the marker tests, a separate, "memory" factor emerged in addition to those of simultaneous and successive synthesis. There are indications from the secondary loadings of recall that successive processing may precede simultaneous in certain tasks. Present evidence involves the recall of words processed with varying degrees of elaboration, while past studies of reading ability have suggested a similar successive-simultaneous progression, developmentally (Cummins & Das, 1977). Results were discussed in terms of their potential practical application, and in terms of the utility of including the planning dimension in future research.

ACKNOWLEDGEMENTS

I would like to express gratitude to those from whom I have learned; in ways not evidenced in the context of an academic thesis.

To my research supervisor, Dr. Robert Mulcahy, who shared his knowledge, time, and enthusiasm so willingly. From Bob I have learned that the production of high quality work is truly worth the effort it demands. As a role model, and a friend, he is irreplaceable.

To Drs. Das, Schultz, Schwartz and Wall, for their valuable input and support from candidacy through final oral.

To Dr. Douglas Detterman for his attendance at my oral, his knowledgeable input, and his quiet but solid support.

To the Edmonton Public School Board, for making me welcome within their schools, and allowing me access to the 150 young people with whom I thoroughly enjoyed working.

To Steven, for his patience, love, and sense of perspective. From him I have learned that even the highest goals can be reached if one cares enough, and tries hard enough.

To my mother and father, from whom I have learned a very special value system. From their example, and through their love, I have learned that honesty and integrity are far from obsolete, and that valuing people more than possessions brings its own rewards. Their encouragement and confidence have contributed much to my past and present achievements.

TABLE OF CONTENTS

CHAPTER PAGE

CHAPTER PAGE

LIST OF TABLES

LIST OF FIGURES

Chapter 1

INTRODUCTION

Human information-processing in general refers to the intake or reception of stimulation from the environment, the integration and organization of this stimulation, and the utilization of the information for some form of expression (Safer & Allen, 1976). Several recent theories of information-processing, in contrast to traditional emphases on aspects such as structural memory storehouses, and concrete-ability labels, have focussed on the process of encoding itself. Such a focus allows an emphasis on stimulus reception and the integration and organization of stimuli. For example, Craik and Lockhart (1972) propose a "levels of processing" approach to memory functioning, such that degree of retention depends upon the perceptual analyses and encoding of stimuli, rather than the location of the stimuli in a specific structural memory storehouse such as long or short-term store. They maintain that stimuli may be processed at a shallow, "physical" level, a deeper "phonemic" level, or deeper yet "semantic" level, and that memory performance is increased as stimuli are processed to progressively deeper levels. The concept of "depth" is described by Craik (1973) as being comprised of factors of stimulus intensity and meaningfulness, and amount of processing and attention devoted to the stimulus. Refinements to Craik and Lockhart's theory (Craik & Jacoby, 1975; Lockhart, Craik & Jacoby, 1975) have suggested that stimuli need not be processed progressively through the three levels, but that any stimulus may be processed at any level. Additionally, more elaborate processing may proceed either from one level to the next, or within one

level. Overall, the underlying tenet remains that increased depth of processing results in improved memory performance. The majority of studies investigating levels of processing theory have found it to be a relatively stable concept, offering new insight into the possible processes underlying information-processing and memory (Craik, 1973; Craik & Tulving, 1975; Jenkins, 1974).

Another theory of information-processing which has been gaining prominence in the literature is that of Das, Kirby and Jarman (1975), dealing with simultaneous and successive synthesis. This theory is based on Luria's (1966) model of cognitive functioning, following his studies with brain-damaged patients, and it is relevant for information-processing in general rather than focussing on one element such as memory, as does the levels of processing approach. Das et. al. describe information-processing as consisting of simultaneous synthesis, where various elements are organized into groups and are spatially related; successive synthesis, where various elements are organized into series and are temporally related; or some combination of these two. The two types of synthesis are not presented in hierarchical arrangement, although one may be more efficient for a particular task. The task demands, as well as an individual's genetically or culturally-determined predisposition to respond a certain way, are the influential factors in the choice of simultaneous or successive synthesis. Using a battery of tests, including standardized tests of reasoning and memory, as well as tests involving visual-motor and cross-modal coding, Das and his colleagues found that factor analyses indeed produced loadings on two factors, which seemed to be appropriately labelled as simultaneous and successive integration. These two factors, as well as an additional

reliable factor which the authors label as a "speed" factor, have been found for groups differing in I.Q. level, age, socio-economic level, and over differing cultural groups (Das, 1973; Das, Kirby & Jarman, 1975; Molloy, 1973). Some variations in the factor loadings for specific tests were found, particularly for groups having wide ranges in intellectual level, or cultural background. In general, experimental results have supported the notion of simultaneous and successive synthesis (Kirby & Das, 1978; Lawson, 1976), and the theory itself offers a process-based explanation of information-processing overall.

Results of adult studies of levels of processing (Craik & Tulving, 1975; Lawson, 1976), and factor analytic "comparison-group" studies of simultaneous-successive synthesis (Das, Kirby & Jarman, 1975; Kirby & Das, 1978) have provided encouraging results in support of particular cognitive processes underlying memory functioning, and information-processing as a whole. One area which has received very little attention to date has been the development of such cognitive processes with increasing age. That such development is to be expected receives support from theories of cognitive functioning (Piaget, 1968), and descriptions of increasing perceptual sophistication (Wepman, 1975) and a perceptual-verbal encoding shift (Cramer, 1976) with increasing age. The discovery of developmental changes in the ways in which children characteristically process information, or developmental differences in the effects of processing levels for memory performance, would provide valuable data in two ways. Firstly, it would increase our understanding of human learning, and cognitive functioning related to information-processing. Additionally, a very practical contribution would be provided in that, if it becomes known how children at particular ages

most efficiently process material, or how materials are processed for most efficient memory performance, one can prepare educational materials accordingly, for added expedience in the general learning process.

The two main studies to date which have addressed the relationship of levels of processing and developmental levels have left several questions unanswered (Geis & Hall, 1976; Lawson, 1976). Though both studies have provided general support for the notion of depth of processing and retention, there is still question as to the applicability of three distinct levels of processing, the possibility that preference for particular attributes may affect children's memory as well as levels, and the notion that a comprehensive developmental study must utilize a wider age-range than that employed in either of the aforementioned studies. In the major study examining simultaneous-successive processing within a developmental context, Molloy (1973) reported the stability of Das et.al.'s three factors. Though disparities in factor loadings over differing tasks has mainly occurred for groups differing widely in I.Q. or cultural background, there are indications that developmental changes in such loadings also occur. Once again differences may become more obvious through the use of a wider age range than that used by Molloy.

The main purpose of this study is to examine, first, levels of processing, and secondly the dimension of simultaneous-successive synthesis, within a developmental framework, to discover possible shifts in preference or competency dimensions of information-processing with increases in age. Inclusion of recall results in a factor analysis with simultaneous-successive tasks also provides an initial exploration

of the contributions of these modes of processing to the levels task, for various age groups.

In addition, the present experimental paradigm allows the examination of both incidental and intentional learning conditions. Past research has indicated that older children perform better on recall tasks than do younger children, when they are given instructions to remember (Cole, Frankel, & Sharp, 1971; Laurence, 1966). Within a levels of analysis study, it is possible to compare the effects of incidental versus intentional learning condition on the memory performance of children of increasing ages, and also on the recall of information processed to varying depths..

Chapter II

SELECTIVE REVIEW OF THE LITERATURE

Theories of Memory

Until the last decade, models of information-processing and memory have focussed primarily on structural aspects of memory, with memory stores represented by boxes, and information transfer between boxes represented by flow diagrams (Atkinson & Shiffrin, 1968; Broadbent, 1958; Waugh & Norman, 1965). The three main storage mechanisms postulated within the memory system are sensory store, short-term store, and long-term store. With regard to transfer between the stores, information first enters the sensory store, and decays rapidly unless specific aspects are attended to, the latter resulting in transference to the limited capacity, short-term memory store. Information in short-term memory is transferred to long-term storage if it remains long enough (for example, five seconds) without being displaced by newer, incoming items. Most models tended to emphasize the nature of the memory boxes themselves, as opposed to the arrows between them, although minimal attention was at times given to process. For example, mention was made in Waugh and Norman (1965) of rehearsal processes (recirculation of items in short-term storage) which were instrumental in the transfer of information between primary memory (a limited capacity store) and secondary, long-term memory. As well, Atkinson and Shiffrin (1968) see rehearsal as a process, under control of the subject, which may be utilized for information in short-term memory and may result in its transfer to a long-term store. However, there was little emphasis placed on the processes underlying memory until theoretical

papers began to attend to the possible "nature" of the memory trace, and until Craik and Lockhart (1972) proposed their "process-based" theory of memory functions.

Briefly, in discussions of the nature of memory traces themselves, the emphasis began shifting from structural stores to events occurring during encoding itself, as determinants of memory performance. Underwood's (1969, 1972) view that a memory trace consists of a "grouping of attributes" is representative of several which were proposed (Bower, 1967; Tulving & Bower, 1974). Underwood felt that the encoding of particular attributes (for example, temporal and spatial) provided mainly discriminative functions which could be utilized in recognition. Associative attributes on the other hand had retrieval functions, and in recall were utilized as well as discriminative attributes. Underwood suggested that the attributes most prominent in a child's encoding and therefore his memory may shift with development, from "perceptual" to "verbal". This focus on the importance of encoding for memory is also maintained in the theory of Craik and Lockhart (1972).

Prior to the presentation of their own "levels of processing" theory of memory, Craik and Lockhart argued against the general applicability of the multi-store models, described previously. They admit that a capacity limit is possible for the central processor, but argue against a limited capacity in short-term store (STS), since capacity estimates for STS in the literature have varied so widely. Craik and Lockhart question the proposed capacity limitations, and forgetting characteristics of the three stores. They maintain that if these differences exist, they should be invariant across situations and stimuli, but that short-term retention, for example, varies with method of

stimuli presentation. These authors argue that amount and meaningfulness of material, familiarity, etc., affect retention at any one time, and that retention is thus not a function of either short-term or long-term storage alone. The concept of interactive determinants of recall has been further underlined in recent studies (Jacoby, Bartz & Evans, 1978; Reese, 1976). Craik and Lockhart prefer to examine encoding operations as opposed to memory stores, and they view forgetting as a function of level of encoding. They also oppose the notion that short-term memory is involved exclusively with acoustic, and long-term with semantic encoding (Conrad, 1964), as well as the segmentation of the memory system, which they see much more as a continuum of perceptual analysis.

Levels of Analysis

As an alternative to the multi-store models of memory, Craik and Lockhart (1972) propose a "levels of processing" approach to human memory, which emphasizes the perceptual analyses and encoding of stimuli. Essentially, incoming stimuli may be analyzed or processed at a shallow, "physical" level, a deeper "phonemic" level, or a deeper yet "semantic" level, and the persistence of a memory trace increases as one moves along the continuum towards deeper levels of processing. Within their model Craik and Lockhart endorse two types of rehearsal. Elaborative rehearsal involves the processing of stimuli to deeper levels (thus increasing the strength of the memory trace), while maintenance rehearsal involves continued processing at the same level of analysis, which will prolong an item's accessibility without actually increasing the durability of the memory trace (Mazuryk & Lockhart, 1974).

The general notion of depth of processing and its influence on retention have been retained, although refinements have been made to the original model (Craik & Jacoby, 1975; Lockhart, Craik & Jacoby, 1975). In the initial theory the only definition for depth of analysis involved progression from the physical through the semantic levels. Later, more comprehensive definitions included an increase in the accessibility of an item within a level, which was also included under the rubric of "depth". For example, the latter authors have suggested that incoming information is analyzed either laterally or vertically within three "qualitatively coherent" domains, rather than necessarily proceeding through the levels of hierarchical analysis. Further processing then can proceed either between domains, or within a domain, and in both cases the increasing "depth" of processing serves to make a richer memory trace. This concept of "spread of processing" within a domain helps account for the effects of novelty or familiarity of a stimulus. For example, a familiar or highly practised semantic task may be performed easily and quickly, while a novel semantic task may involve more processing time and effort initially.

The concepts of episodic and semantic memory have been incorporated into Craik and Lockhart's original theory. Episodic memory is the portion of the perceptual-memory system wherein specific events and episodes are stored in temporal order. These temporally-ordered traces may become incorporated eventually, into the more permanent memory system. Semantic memory is essentially an individual's storehouse of general knowledge, and it is made up of laws, rules and procedures for interpreting incoming stimuli. The two memory systems are seen as being interdependent. Semantic memory is actually structured

from episodic traces, and episodic traces may be activated by relevant activation in semantic memory. Looking at these concepts in terms of retrieval strategies, an individual may "scan" recent episodic traces for salient aspects of a stimulus, or utilize the "retrieval-by-reconstruction" method, whereby a remote or recent event is reconstructed in the perceptual-memory system through the influence of the recognition stimulus and the episode trace. The involvement of the latter would appear to be a case in which episode traces may be activated in semantic memory.

Recent studies of levels of analysis have been more cautious about accepting the concept of depth as an adequate explanation of retention. Craik (1977) outlined four principles which he felt exerted major influences on memory function. Depth was retained, since the qualitative nature of a task has been shown to influence retention, but elaboration of encoding, congruity between an event and its encoding context, and uniqueness of the link between encoding and retrieval information were also included as major factors. Moscovitch and Craik (1976) and Jacoby, Bartz and Evans (1978) have also discussed scaled meaningfulness, repetition, retrieval cues, and uniqueness of encoding as determinants of retention, which have interactive effects with those of depth of analysis. The original model is thus becoming more refined, and as such is opening the door to a better overall understanding of memory processes. In summary, the concept of depth of processing per se has retained its importance in recent formulations although constructs other than perceptual/cognitive analyses are being included as well.

Essentially, the proponents of a structural model of memory

attributed retention to the particular location of items in the overall structure, and more process-oriented theorists discussed greater retention in terms of the processes involved in encoding items. In the former, transfer of items from one structural storehouse to another was often discussed in terms of processes such as rehearsal, and these were subsumed under the "arrows" in structural flow diagrams. However, the "process" theorists actually began focussing on the nature and types of rehearsal (for example, chunking, mnemonic devices, elaborative versus maintenance rehearsal), and the attributes of stimuli and types of perceptual attention and processing which affect retention. In a sense the two orientations may not be as disparate as one would think initially. While the structuralists admit to, and "name" particular processes which result in increased retention (albeit in terms of where an item is "stored"), the processes theorists attempt to "define" or explain the processes (subsumed under the flow-diagram arrows), and as such attribute increased retention to processes per se, without discussion of an end product of the arrows in terms of a memory store-house. Both orientations discuss retention in terms of attention, time spent, and number of features analyzed, with increase in these factors in general producing increased retention. However, the move away from segmentation of the memory system, to a view of the system as a continuum of perceptual analysis, offered an opportunity for researchers to concentrate on processes such as encoding, rehearsal, etc., rather than inferring the effects of these completely from post hoc results.

Whether or not the "levels of processing" model differs substantially from the multi-store models may be examined in terms of the differentiation between short and long-term memory stores. Craik (1973)

discussed primary memory (PM) as continued attention to aspects of a stimulus, as opposed to a specific memory storehouse (STM), but both of these concepts imply a non-permanent type of memory trace. Long-term memory (LTM) for the structuralists implies a transfer of information as a result of "rehearsal" processes. Craik (1973) discusses secondary memory (SM) for levels of processing as a result of "elaborative" rehearsal, involving processing to a deeper level, and argues that this type of elaboration or enrichment must occur, over and above mere repetition, for transfer to more permanent storage in the structuralist's theory as well. Both theories entertain notions of permanent, as well as more transient memory traces. The structuralists discuss these in terms of the placement of information in a particular memory storehouse (Atkinson & Shiffrin, 1968), while the process theorists conceptualize length of retention largely in terms of the initial "depth" of processing of an item. The actual operation of both of these theories can be conceptualized through descriptions of the processing, and memory, of words.

The structuralists would discuss retention in terms of transfer of a word from sensory storage to short-term store, following attention to specific aspects. As a result of subject-mediated processes such as rehearsal, material may be held in STM for a long enough period that it becomes transferred to a long-term store. On the other hand, the emphasis in process theories such as that of Craik and Lockhart is on perceptual encoding, rather than the transfer of material from one memory "box" to another. Words as stimuli would tend to have a good likelihood of being processed, even to a small degree, to "deep" semantic levels, since most words have at least some previous associative

connections in semantic memory. When a task demands attention in particular to physical or phonemic aspects of a word, there is less opportunity for the activation of many of these semantic connections than when task demands actually include semantic processing. In as much as some elaboration has accompanied even shallow processing, words processed to these depths may be retained over the long term. Where few connections are made, the general theoretical notion applies that speed of forgetting will be a negative function of depth and spread of encoding.

Empirical tests of the levels of processing theory have been undertaken since its presentation in 1972. Craik (1973) and Jenkins (1974) utilized orienting questions in their memory tasks which required subjects to attend to semantic or non-semantic aspects of words, and found that memory was indeed better for those words processed at "deeper", semantic levels. A series of experiments by Craik and Tulving (1975) were undertaken as a direct test of levels of processing theory. In their first four experiments, these authors found support for the basic tenets of levels of processing theory, in that a linear relationship was found between the depth at which a stimulus was processed, and decision-latency and recall. In experiment five they concluded that recall and recognition were not merely a function of processing time, since a complex physical task took more processing time, yet was less well retained, than a simple semantic task. Experiment seven indicated that congruity may be an important variable during processing. For example, positive and negative categorization made a difference for recall when they resulted in a difference in congruity or richness of encoding during processing. The authors explained that

the latter may occur when congruous responses to the orienting question, for example, are compatible with already existing cognitive structures, and lead to more elaborate encoding and thus more distinct memory traces. In their final experiments, these authors maintain the robustness of levels of processing even using a "looser" framework with group testing procedures and differing presentation rates, and utilizing differential rewards for words processed at different levels.

Lawson (1976) also made use of a series of three experiments to examine further the concepts of depth and spread of processing, but many of his results are less clear-cut than those of Craik and Tulving. For example, although the semantic - non-semantic distinction was upheld in retention data, the physical-phonemic distinction was found to be non-significant. Also the distinction in recall for tasks given "yes" and "no" responses was found only for semantic processing, and not for phonemic or physical. When comparing the results of Craik and Tulving (1975) and Lawson (1976), Shangi, Das & Mulcahy (1978) stated that differences in part may have been a function of methodological differences between the two studies. For example, with Craik and Tulving's study subjects may have had increased vigilance and less distraction in their reaction-time paradigm, whereas in the Lawson study subjects were group tested. However, this does not explain the results for the group tested in Craik and Tulving's series in which classroom testing yielded differences for the three levels of processing, thus supporting levels theory. In addition, though Craik and Tulving definitely "played down" the distinction between incidental and intentional learning conditions within a levels of processing framework, Lawson discusses evidence, including that from his own study, to indicate that

intention to learn may indeed be a factor in encoding, especially for more shallow domain processing.

Though research to date has provided support for levels of processing, the model itself has recently been criticized on theoretical grounds (Baddeley, 1978; Eysenck, 1978). These authors both discuss the fact that there is no adequate operational definition of "depth" of analysis. Studies attempting to use time (Craik & Tulving, 1975) or physiological indices (Shangi, Das & Mulcahy, 1978), to this end have produced inconclusive results. It remains that recall is used as a basic indication of depth of processing, and that depth in turn is defined as having specific effects on recall. This circularity is unacceptable if the levels theory is to be subject to empirical verification or alteration. In their reply to Eysenck, Lockhart and Craik (1978) agree with the problem presented by this circularity, but maintain that levels theory provides a directing force for research on information-processing and memory, and need not at this point have to withstand direct empirical testing. Rather, they view the theory as a new approach to the examination of the relationships between cognitive variables.

Eysenck suggests that the "qualitatively distinct" domains or levels, in levels of processing theory, are non-scientific, subjective categories. Baddeley suggests a need to develop further levels within the phonemic and semantic domains. Lockhart and Craik however support their chosen domains, and the concept of "spread" of processing within a domain, by stating that their model provides for both qualitative and quantitative differences in the nature of the memory trace. They state that qualitative as well as quantitative differences exist for

the traces of material processed to the different levels, but that there is also an added "strength" component within levels, whereby traces are strengthened by maintenance rehearsal.

Both critiques of levels theory have expressed some dissatisfaction with the addition of concepts such as "compatibility", and "elaboration" (Baddeley, 1978), and the fact that environmental factors in addition to encoding operations are being considered as determinants of retention. As an example of the latter, Moscovitch and Craik (1976) have discussed retrieval cues, in addition to encoding, as variables important for retention; a notion originally stressed by Tulving (1974). They found that cueing, uniqueness, and congruence all exerted effects on retention and that these were most pronounced at the deepest level of analysis. These authors concluded that deeper processing or encoding may place a higher ceiling on potential memory, but that conditions for retrieval contribute much to the actual memory performance. Jacoby, Bartz and Evans (1978) brought out other instances of factors influencing encoding in addition to levels per se. They found that the meaningfulness of words themselves, as well as the task, contributed to encoding and subsequent retention. That is, in addition to an orienting question directing one's attention to a word's meaning, the word itself must be rich in meaning if optimal memory is to occur. They also discuss repetition as having a larger effect for deeper levels of processing.

Rather than viewing such findings as contradictory with the notions of levels theory, Lockhart and Craik (1978) integrate them and thus provide for an expansion of the theory. For example, within levels theory there has been acceptance of the effect of distinctiveness of

cues on retention, especially for semantic encoding (Fisher & Craik, 1977; Moscovitch & Craik, 1976). Lockhart and Craik accept and incorporate the notion that retrieval environment influences retention. They also provide evidence that the effectiveness of retrieval cues is also related to the qualitative nature of encoding (Fisher & Craik, 1977), such that it is the interaction of encoding and retrieval environments, and neither separately which is most meaningful in predicting retention. The acceptance of such interactional effects within levels theory indicates a progression of the theory since it's original empirical test by Craik and Tulving (1975). At that time the authors negated the effects of variables such as intention to remember, task difficulty, as well as the time and effort expended, and attributed retention to the qualitative nature of encoding per se.

As mentioned previously, levels of analysis has provided a core for theories of memory, and through research this core is gradually becoming elaborated into a more complex and detailed theory. The levels of processing model offers a new, "process-oriented approach" to the study of human memory. The general concept of depth appears to be a stable one, and provides a potentially useful manner of examining in greater detail adult memory as well as the development of memory in children.

A critique of the application of levels theory to developmental memory (Naus, 1978) will be presented in a later section.

Developmental Memory

Developmental studies of memory have tended to emphasize two areas which differentiate memory processes for adults and children. One area includes a "production deficiency" for children, such that certain

strategies which would facilitate memory performance are not employed (Flavell, 1970). There have been many recent studies indicating that strategies such as rehearsal are indeed utilized less by younger children, and that spontaneous rehearsal strategies themselves develop and become more sophisticated with increasing age (Allik & Siegel, 1976; Frank & Rabinovitch, 1974; Ornstein, Naus & Liberty, 1976). Additionally, support is provided for the notion that young children possess a production, as opposed to a mediational deficiency, by the fact that rehearsal strategies can be effectively taught to them (Ashcroft & Kellas, 1974; Belmont & Butterfield, 1971). It does, however, remain difficult to prove when, or if, a mediational deficiency (for example in pre-language children) gives way to a production deficiency. For example, one could always argue that, in defined "mediational" deficiencies we have only to discover the appropriate method to teach and induce production. However, exhausting all possible methods of instruction would be a formidable task (Brown, 1974).

Another area proposed to differentiate adult and child memory processes involves the theory of Underwood (1969) that a memory trace is an "ensemble of attributes" which is laid down during stimulus encoding or processing. There is evidence that young children may be more sensitive to, and more affected by, a differing set of attributes than those which affect older children. For example, Bach and Underwood (1970) found more false recognitions for acoustic distractors as opposed to semantic distractors for grades two and three than for grade six. Felzen and Anisfeld (1970) found that both grade three and grade six students were sensitive to acoustic distractors in a continuous recognition task, but that the potency of semantic distractors

increased with increasing age. More recent studies have reported similar results, in that young children are more likely to encode acoustic or physical features of words or pictures, while older children attend more to the semantic features of the word (Freund & Johnson, 1972; Hasher & Clifton, 1974; Means & Rohwer, 1976).

Levels of Analysis and Development

Though Craik and Lockhart's (1972) framework involving different levels of processing has been applied mainly to adult populations, it also appears to have much utility for examining factors such as memory and attention within a developmental context. Looking only at the evidence presented to this point, it is possible to generate three hypotheses pertaining to a levels of processing paradigm involving children of varying ages:

1. Craik and Lockhart proposed that retention is directly related to the depth at which a stimulus is processed. For example, incoming stimuli are subjected to particular stages of analysis with attention to physical, phonemic, or semantic attributes of a stimulus, and the persistence of a memory trace increases as one moves along the continuum towards deeper levels of processing. A direct application of Craik and Lockhart's theory would lead one to expect that developmental differences in retention would be a result of older children spontaneously processing materials to "deeper" levels (perhaps utilizing more elaboration, etc.). Such a hypothesis retains the assumption that young children have a production, as opposed to a mediational, deficiency. Orienting questions in levels of processing paradigms essentially "induce" processing at particular levels. Thus if depth of processing

is the sole influence on performance, children at various ages should have equivalent memory performance, differing only within age groups, and for different levels of processing.

2. If one emphasizes the previously-discussed theories of "attribute-preference" of children at different ages, another hypothesis of memory performance following a levels of processing experiment emerges. If attribute-preference is the major factor influencing retention, then it may be expected that younger children will have superior retention for stimuli following induced processing at physical, or phonemic levels. Older children and adults would be expected to have superior retention following induced semantic encoding.

3. Combining the levels of processing and attribute-preference positions one may expect an interaction in the results following a levels of processing task. For example, the advantage to younger children of physical or phonemic encoding may be offset by the effects of induced semantic encoding, which involves a deeper level of processing. In such a case the retention results for younger children may be comparable over all levels of induced processing. On the other hand, retention of semantically processed material should be excellent for older children, since it involves deep levels of processing and is their preferred mode of processing. This combination of the effects of levels of processing and attribute-preference, as well as the overall difference in memory performance for varying age groups, are viewed as the main factors affecting recall results in the present experiment.

Critique of Levels Theory for Developmental Memory

Naus (1978) discussed the applicability of levels of processing

theory to developmental memory. She was critical of the general, descriptive nature of levels theory, and suggested that it is age-related changes in rehearsal activity, and thus mnemonic strategies, which are the critical determinants of retention. In addition, Naus presented some evidence to suggest that a child's knowledge-base can affect retention, apart from either encoding or rehearsal. She stated that levels theory does not allow for the development and operation of such a knowledge base. Finally, Naus concluded that any model of memory must include discussions of "automatic" memory processes as well as those instigated through intent.

In response to these criticisms, data from a considerable number of recent studies suggest that levels theory is becoming more refined, and that Naus's relative dismissal of its relevance is at best premature (Craik & Moscovitch, 1976; Fisher & Craik, 1977). Recent evidence has indicated that qualitative differences in stimulus encoding must be taken into account (Craik, 1977; Fisher & Craik, 1977), and that there are also ensuing processes such as elaboration and repetition which influence retention (Craik, 1977; Craik & Tulving, 1975; Jacoby, Bartz & Evans, 1978). Factors affecting retrieval such as cueing, uniqueness, congruency, and response mode, have also been included as determinants of memory (Craik, 1977; Craik & Moscovitch, 1976). The rehearsal content discussed by Naus may be incorporated into the above list of factors as a method of elaboration and/or repetition (Naus, Ornstein & Aivano, 1977). Rather than attempting to "replace" the concept of levels with that of rehearsal as the major factor affecting developmental memory (Naus, 1978), it would seem more beneficial to incorporate all of the previously described factors within one general

theoretical approach. The descriptive nature of levels theory provides for such incorporation and refinement.

There is evidence to suggest that levels of analysis influence retention over and above the effects of intentionality (Craik & Tulving, 1975; Jacoby, Bartz and Evans, 1978). That is, even when intentional subjects actively "rehearse", or by cognitive operations are able to retain stimuli better than incidental subjects, a levels effect occurs. If rehearsal was the main influence on retention one would expect the levels effect to be eliminated in an intentional condition, but instead there appears to be an interaction between initial encoding, and efforts to try and remember stimuli (Jacoby, Bartz & Evans, 1978).

Since encoding per se has been found consistent over development (Geis & Hall, 1976), it remains to examine the interactional effects of levels with such variables as intentionality, and factors such as congruence, uniqueness, etc. which affect retrieval. Only by such detailed examination, over development, does it become possible to estimate with reasonable accuracy the ages at which particular cognitive changes occur. We may then be in a better position to determine the extent of hypothesized "production deficiencies" in children, affecting areas such as rehearsal content, and the use of instructions to remember.

Contrary to Naus's statements, refinements to the initial levels of processing theory provide for the development and operation of a "knowledge'base". Lockhart, Craik and Jacoby (1975) discuss two types of memory within the levels system. Episodic memory consists of relatively recent, temporally-ordered perceptual memory traces. These traces may eventually become incorporated into the more

permanent, "semantic" memory, which consists of a storehouse of one's general knowledge, and laws and rules for interpreting incoming stimuli. As a child develops, he would have more experiences, resulting in the incorporation of more material into semantic memory. It follows that, with a greater knowledge base in semantic memory, there is more opportunity for incoming stimuli to have many, specific associations within this base, and that subsequent retrieval would be facilitated.

The above discussion suggests that there is no one factor which can, in isolation, provide an explanation of developmental memory. In line with many recent researchers (Craik, 1977; Craik & Moscovitch, 1976; Fisher & Craik, 1977; Jacoby, Bartz & Evans, 1978) it is suggested that the most efficient route to the understanding of retention over development is to examine the effects of specific variations in factors such as encoding level, intentionality, and response mode. (Efforts to look at intentional versus incidental learning may provide initial information as to the "automatic" memory component discussed by Naus.) The present study will be an attempt to examine the effects of several specific variables upon developmental memory.

Some Empirical Evidence

Few studies have examined levels of processing within a developmental framework, and two of the most recent have had conflicting results. Geis and Hall (1976) studied recall after orthographic, acoustic, or semantic processing of words, in children from grades one, three and five. The levels of processing theory was directly supported by their data, in that depth of encoidng determined recall

performance. These authors felt that activity at the time of encoding (that is, levels of processing) may be more important for retention than activity at the time of retrieval, since recall differences did not support the usual finding of superior retention performance with increasing age. Within this study there was no apparent effect for attribute-preference in differing age groups. These authors feel that developmental differences in recall may have resulted if "optional" rather than "obligatory" stimuli had been used, since it is more the spontaneous elaborative processes such as constructing images which differentiate children at differing age levels.

It may be, however, that retention differences, and indications of attribute-preference, if these indeed are sensitive to developmental factors, may become apparent through the use of a somewhat wider age range. Geis and Hall had subjects whose mean ages varied from 7.1 to 11.1 years. However, based on a Piagetian framework, the variance in cognitive development and aspects of attention may be more obvious with subjects, for example, at ages six, eleven and sixteen.

Briefly, Piaget's theory of learning and development involves a cognitively-based approach to these topics. Knowledge and intelligence are viewed as gradual results of an interaction between the child and his environment. The sophistication with which a child represents his world cognitively depends upon his "stage" of development, and each successive stage involves a more advanced level of "adaptation".

Piaget in turn discusses adaptation as a balance between two cognitive processes as a person interacts with his environment. These processes are assimilation, or reacting to the environment in terms of a previously learned response, and accommodation, or altering behavior

as a result of interaction with the environment. Though these cognitive processes are described in Piaget's terms as underlying all behavior, they also have some similarity to the two postulated types of memory in levels of processing theory. Assimilating aspects of the environment to cognitive structure is somewhat comparable to episodic memory traces which are laid down during the processing of stimuli which conform to past rules and regularities (making up semantic memory). Modifying or accommodating structure to aspects of the environment may be compared to the change in structure of semantic memory resulting when events or stimuli are presented in some novel fashion.

The types of cognitive processing which Piaget discusses are thus applicable to the kinds of processing assumed to underly memory performance in a levels of processing framework.

Piaget also discusses very young children as being "perception-dominated," whereas after about age six or seven, they gradually become more able to reason logically using verbal symbols.

Since cognitive development as described by Piaget can be seen as having some application to memory and levels of processing, and also to perceptual attribute preferences for children of varying ages, Piaget's "stages" are appropriate divisions when examining developmental differences for recall following a levels of processing task.

Using Piaget's model of cognitive development, it can be seen that major shifts are proposed at approximately ages five to seven years, and ages eleven to twelve (Bee, 1975). "Pre-operational thought," wherein a child can represent an object to himself through a mental image or word, but still has internal representations tied to specific events, shifts to "concrete operations," at about age six, and

some authors maintain that this shift may be in progress as late as age nine. With the development of concrete operations, the child is able to add, subtract, put things in serial order, classify objects, and "conserve". The development of abstract thinking, deductive reasoning (from a general rule to a specific situation), and the ability to formulate and test hypotheses, occur only after the stage of "formal operations" has been reached, and this Piaget reports as occurring around age eleven or twelve, and continuing often into adulthood (in fact some adults never attain this developmental level). Changes have also been reported in a child's observed approach to learning problems over Piaget's described periods of mental development (Bee, 1975).

Thus a developmental study which spans the ages between six and sixteen years should tap groups which are at different levels of "cognitive development," and concurrently should increase the probability of indexing any developmental factors which are influential. As an example, a child may shift from a "perceptual" to a "verbal" orientation as he passes through Piaget's cognitive stages of development, and this could affect both levels of processing and attribute preference. In terms of levels of processing theory, younger children in this case would be seen as having an encoding "preference" for the more "perceptual" physical and phonemic attributes of stimuli. Older children such as the 16 year olds would be more sensitive to the 'verbal' or semantic attributes. Such differences may be conceptualized as a result of a 'production-type deficiency' in the younger children. That is, though the latter are in fact able to process semantically, they may exhibit a sensitivity or preference for more perceptual types of encoding until a certain degree of cognitive sophistication develops.

Support for specific developmental memory differences comes from a study by Nishikawa (1975) in which memory was found to be more specialized with increasing age, and in which the particular developmental stages which he outlined corresponded with Piaget's stages. Developmental differences in memory performance have also been reported in Soviet research. Barkhatova (1964), in developmental studies of speed and accuracy of recall, found differences in the qualitative aspects of memory performance for children of varying ages. Grade two children used a rather mechanical approach, linking certain items in a series, but not grouping items in any logical way. There was a distinct improvement found in the mnemonic devices used by fifth-graders, and again with those used by eighth-graders, with attempts to find reasonable ways to group and remember stimuli. With college students it was discovered that there was a relative mastery of mnemonic devices, and these generalized to memory requirements involving many different types of material.

In a study involving memory organization as a function of age, Cramer (1976) found that visual (perceptual) encoding is predominant for first-graders while both visual and verbal encoding occur with fourth-graders. (Developmental changes involving improved auditory discrimination and auditory memory span are also reported about age five through eight, and underline the increasing sophistication of perceptual functioning with age (Wepman, 1975).)

The second study of levels of processing in children is that of Lawson (1976). Grade four children were given physical, phonemic, or semantic orienting tasks to perform on words in a study list, and were later tested for either recall or recognition. It was found that

recall results were similar to those of college students, in that semantic processing was superior to physical or phonemic processing for later recall. With recognition it was found that both semantic and phonemic processing were effective, and that phonemic cues were much more salient than they had been for the college students. Thus there is some indication that attribute-preference may exist as a developmental phonemenon although Lawson feels that there may have been a ceiling effect for retention following semantic processing in the recognition group.

A developmental study involving levels of processing, with a relatively wide range of subject ages, should provide some insight into questions emanating from the previous discussion. In addition, the use of free recall as well as a recognition task, provides for examination of these two response modes in terms of past and recent theoretical descriptions (Kintsch, 1970; Lockhart, Craik and Jacoby, 1975). It is also an attempt to provide an alternative analysis should recall results produce a floor effect for young subjects (Geis & Hall, 1976).

Overall it appears that depth of processing would exert a major influence on the memory performance of children at all ages, but that some developmental differences, due to perceptual and cognitive maturation, would be expected. Such differences may include different attribute preferences at various ages, and differing reactions over age to variables such as intentional versus incidental learning condition, or recall versus recognition response.

Retention level has in some cases been found to vary according to one's intention to learn (Lawson, 1976). Particularly in a levels of analysis paradigm, it is of interest to further examine indications

that older children are more sensitive to instructions to remember than are younger ones (Cole, Frankel & Sharp, 1971; Zinchenko, 1972). In this way it becomes possible to analyze and discuss any interactive effects of depth of encoding, and learning set, for children at various ages. An examination of the intentional-incidental variables will be undertaken at this point.

Incidental and Intentional Learning

Intention to learn may be viewed as an added dimension which affects the encoding and performance on any given memory task. A certain amount of support for the notion that intentional learning is more effective than incidental learning is provided in adult research. Intention to learn has been found effective in a levels of processing paradigm (Lawson, 1976), and there is some evidence to indicate that it is more effective for shallow than deep domain processing (Jacoby & Goolkasian, 1973; Lawson, 1976; Treisman & Tuxworth, 1974). Jacoby and Goolkasian (1973) had subjects compare words on either an acoustic or a semantic dimension. Instructions to learn resulted in improved memory performance for the "acoustic" words, while words which had been related on the basis of meaning were remembered equally well under intentional and incidental learning conditions. Within Lawson's study of levels of processing, subjects in an intentional learning condition had better recall performance overall than subjects in an incidental condition. Subjects who were preparing for a recall task had better retention of material processed to shallow levels than did subjects preparing for a recognition task. Lawson discussed this in terms of the idea that, when recall is expected, individuals subject shallow domain items to further intradomain rehearsal in an attempt to

better remember them. (The latter may be more relevant for recall than recognition since more cues of an internal nature are necessary in retrieval of the former.) The deeper, semantic level leaves less room for such further processing and indeed semantic items were better retained than other items in both intentional and incidental conditions. Thus the intention to learn can affect subsequent memory performance, and it probably has a differential effect depending upon the type of processing involved. In a levels of processing paradigm, it is speculated that the shallow depths of processing provide more opportunity for elaborative rehearsal, etc., than does the deeper semantic level, and thus are more open to improvement in retention of the stimuli. In this case material processed to a semantic level would be seen as exhibiting a "ceiling effect" for memory performance.

In spite of the fact that there may be some amount of elaborative rehearsal resulting from intention to remember at all levels, there is evidence to suggest that it is maintenance rehearsal which produces the most pronounced effect (Mazuryk & Lockhart, 1974; Walsh & Jenkins, 1973). Even in a paradigm requiring covert rehearsal, those with instructions to remember retained the relative differences in retention according to the manner in which stimuli had been initially encoded. Thus it appears that actual elaborative efforts, if they occur, are not of the magnitude to actually promote a deeper level of analysis than that required by the orienting task. At all three levels of analysis, intentionality is seen mainly as promoting maintenance rehearsal efforts.

Craik and Tulving (1975), in a series of experiments designed to test levels of processing theory, tended to minimize the effect of

different learning sets, although their results actually were in support of such an effect. For example, although knowledge of recall tasks had no observable effect on response latency, it resulted in superior recall performance with $p < .01$! Subjects who were aware of the recall task had apparently engaged in some cognitive activity which improved their retention over that of subjects without such knowledge. (In this case, the cognitive activity may be described as maintenance rehearsal since the usual heirarchy of levels remained in the results for the intentional group.) It is difficult to reconcile such a finding, with Craik & Tulving's statement's that, "The operations carried out on the material, and not the intention to learn, as such, determine retention (p. 269)." "Operations", in terms of the levels at which stimuli are processed, do exert a major influence on memory performance, but at the same time the effect of learning set cannot be denied, and it remains a variable worthy of empirical consideration.

Recent studies such as that of Geis and Hall (1976) have relied mainly on incidental learning paradigms. However, the effects of learning condition must be investigated further, since Craik (1977) found no difference in retention for incidental and intentional groups when the imperative word was presented prior to the orienting question. This suggests that intentionality may exert a different influence under varying experimental conditions.

Intentionality has also been examined within a developmental framework. Studies such as those of Cole, Frankel, and Sharp (1971) and Laurence (1966) have shown that older children have superior recall, in a standard free recall task, under intentional learning conditions. There is further evidence which indicates that both intentional and

incidental learning are affected by the age of the children involved, and that a pattern exists for the development, and relative superiority of each type of learning set, with increasing age.

Results of studies of attention and distractibility in children may be utilized as indications of the effects of intentional and incidental learning. As an example, Maccoby (1967) discusses a task wherein children were asked to remember the serial position of certain cards. On each card was a line drawing of an animal, and a picture of a familiar household object. Over many trials, children were told to attend to the animals only, and the authors refer to the memory for these animals as "central recall." Subjects were then instructed to match each animal with the correct household object, and memory in this case was termed "incidental recall." Since subjects were told to pay attention to the animals, this is viewed as being comparable to an intentional learning set, while the household objects were obviously part of an incidental learning paradigm. Hagen and his colleagues (Drucker & Hagen, 1969; Hagen & Huntsman, 1971) found a developmental increase in the ability of normal children to attend to central information, and thus in a sense to utilize an intentional learning set. At about age 12 to 13 years, the authors found that incidental recall dropped off, while central recall continued to rise. Prior to 12 years there had been a generally positive relationship between central and incidental recall, and following 12 or 13 the relationship became negative. This leads to obvious speculations that older children have developed attentional strategies to such a degree that the intentional, or central task is learned much better than material presented incidentally. Thus, in intentional learning tasks, they may be expected to

perform better than younger children, while in incidental paradigms there should be less differentiation between the memory performance of the two groups.

The Soviet researcher Zinchenko (1962) used a paradigm which has many properties in common with a levels of processing task, using both incidental and intentional learning conditions. Zinchenko's subjects were presented with stimulus words, and for each they were required to think of a second word, which was related to the first in one of three ways. The second word had to possess a meaningful (semantic) relationship with the first (for example, hammer-nail), a property (semantic) relationship (for example, house-wood), or had to begin with the same letter as the first word (physical attribute). The procedure has definite similarities with Craik and Lockhart's (1972) levels of processing approach, wherein processing may occur at a semantic, phonemic, or physical level.

Zinchenko used subjects of preschool age, and at grade two and grade five levels. The task was presented either in conditions of play (incidental learning set) or academic competition (intentional learning set). Results for memory performance are similar to those in experiments of levels of analysis, in that recall improved for stimulus words having physical, property-related, and semantically-related "connectors," respectively. Also, the intentional condition was found to be most effective in improving the recall of grade five students, and least effective for preschoolers. This provides a further indication that developmental differences may exist for the effects of "intention to learn."

In the two studies which touched on development and levels of

processing (Geis & Hall, 1976; Lawson, 1976) to date, incidental learning paradigms were used. Geis and Hall state that they used an incidental paradigm because they wanted to examine developmental differences in processing and memory apart from those incurred through instructions to learn. These authors felt that the superior memory skills of older children, in terms of more sophisticated rehearsal strategies, etc., had already been established in studies of intentional learning, and they wanted to examine processing without these "interfering variables." The present study incorporates such an incidental paradigm, but also includes an intentional group for levels of processing tasks at each age level. Such comparative groups can provide vital information as to developmental differences related to processing requirements per se, and differences which result from the addition of "intention to learn" as a variable over and above depth of processing.

The preceding discussion has focussed primarily on aspects of information-processing which are related to memory performance. However, more generic theorists have also been of interest to information processing theorists, and in the following section one such theory will be discussed.

Simultaneous and Successive Synthesis

Following the early work of Binet (1903), psychological and educational theorists tended to emphasize concrete indices of intellectual ability, such as the I.Q. score. However, such a "power" measure does not provide much information as to the processes involved in particular cognitive tasks. Therefore many recent theorists have focussed on the cognitive processes believed to underlie abilities in

an attempt to determine individual variations in the ways people perceive information, store it, and remember it (Carroll, 1976; Estes, 1974; Kogan, 1971).

Prior to this upsurge of interest in processes, ability theorists had varying ways of describing mental functioning. In large part these descriptions were based on the results of correlational techniques, specifically factor analysis (Spearman, 1927; Vernon, 1969). Following the administration of many cognitive tasks, a researcher could group those tasks whose results were found to be correlated with each other, and then hypothesize (and typically name) the mental ability or factor thought to subsume performance on the given tasks. Many factor analytic studies have proposed a "general factor" of intelligence which affects performance on all cognitive tasks, and specific factors which tend to be more involved with discrete tasks.

A hierarchical structure of mental abilities was proposed by Burt (1949), and this notion has also been advanced more recently. Vernon (1969) and McFarlane-Smith (1964) conceptualize a hierarchy involving generalized ability, as described above, which divides successively into more specialized abilities. Within the context of their hierarchy, memory ability is at a lower level than are reasoning and abstraction. Similarly, Jensen (1970) hypothesizes two main levels of mental ability, with the lower level (Level I) encompassing "associative learning ability" or memory, and the upper level (Level II) involving reasoning ability. Level I is viewed as a necessary, though not sufficient prerequisite for functioning at Level II. Jensen hints that differing processes underly each level, as he describes Level I as involving the ability to receive, store and recall

stimuli and Level II as the ability to transform stimulus input and arrive at some judgment. Thus it appears that this transformation, or "processing" of information may be a critical differentiating factor between memory and reasoning. However, Jensen does not take this notion to the next logical step, in that he does not consider how stimuli may be transformed. It is this consideration of the processes involved in cognitive functioning, as opposed to "outcome measures" in the form of abilities, which has led to a new direction of focus for many researchers.

Attempts have been made to discover the cognitive processes which enhance or detract from performance on particular psychometric tests (Carroll, 1976; Estes, 1974) and to discover those processes underlying verbal as opposed to quantitative abilities (Hunt & Lansman, 1975). One approach which has had considerable support for its description of cognitive processing is that of Das, Kirby and Jarman (1975). These authors based their notion of simultaneous and successive processing on the results of clinical studies carried out by Luria (1966). Prior to a discussion of the implications of this approach, it is of interest to note its historical development.

As mentioned previously, the roots of simultaneous-successive processing theory lie in Luria's work with brain-damaged patients. Luria developed his own model of cognitive functioning following examinations of persons with left hemisphere brain damage. He found that lesions in the occipital-parietal area resulted in a disturbance in the simultaneous processing of stimuli, while lesions in the frontotemporal area resulted in disturbances in more serial, or successive processing. Luria proposed that the brain employs these two mutually

dependent modes of coding information and that they in fact underly all forms of information-processing. Simultaneous processing or synthesis involves the synthesis of various separate elements into groups, with spatial overtones such that all parts of the group are accessible regardless of their position in the group. Successive synthesis involves the integration of separate elements into a series, or groups which are related temporally rather than spatially. Accessibility depends upon the temporal order of the series. Simultaneous processing is utilized when one deals with relationships between variables, or when information is brought together in the form of a gestalt. Successive processing is utilized when one formulates or produces some series of events. Unlike Jensen, Luria does not propose an overall hierarchical arrangement for his two modes of processing, although for particular tasks one mode may prove more efficient. Both modes are influential in direct perception, mnestic processes or memory, and more complex intellectual processes. Factor analytic studies have tended to emphasize the latter two types of processing, since they are at the forefront in cognitive processing.

Das and his colleagues include four units -- input, sensory register, central processing unit, and output, in their "information-integration" model. Sensory information may be either simultaneous or successive, and in the sensory register processing may be either serial or parallel. The central processing unit then engages in simultaneous or successive processing, and carries out decision-making and planning based on information from this processing. Output finally organizes the product of processing, in accordance with task demands.

The implications of such an approach to information-processing tend to be far-reaching. Das and his colleagues have utilized factor analysis with a chosen battery of tests to indicate that simultaneous and successive processing emerge as distinct factors across differing cultural and age groups, and differing achievement and SES levels (Das, Kirby & Jarman, 1975). As a result of their analyses of many tests, they also discuss the emergence of a third stable factor called "speed", which they feel indexes speed of integration of information.

Rather than beginning with several tasks and attempting to find out the processes involved in each, Das et. al. began with a hypothesis that all tasks involve two main processes, which may appear singly or in combination depending upon the task, and genetic or socio-cultural characteristics of the individual. This is not inconsistent with approaches such as those of Estes (1974) and Hunt and Lansman (1975), but is rather an attack on the same issue from an opposite angle. The former are in a sense looking for discrete information, while Das et. al. are looking for support for an "all-inclusive" hypothesis, with respect to processes in information-processing.

The concept of simultaneous and successive processing similarly is not inconsistent with descriptions of relatively concrete abilities; it is rather more a qualitative, as opposed to a quantitative, way of viewing cognitive functions. Comparisons have in fact been made between particular "abilities," such as MacFarlane-Smith's (1964) specific spatial ability, and the concept of simultaneous processing, since in both cases there are indications that material must be perceived, organized and maintained as a whole.

Das et. al. would, however, be concerned about particular factor

labels and their appropriateness in a hierarchy of abilities (that is, Jensen's Level I and Level II). For example, in factor analyses (Das, 1972), it was found that disparate loadings occurred on tasks supposedly measuring memory, for normal and retarded children, thus the generalizability of Jensen's levels comes into question. Additionally, if the factors themselves have questionable validity; that is, if tests purported to measure each have differing results for different subject populations, then the concept of a hierarchy of factors also loses much of its meaning. (In a recent article by Jarman (1978), Jensen's Level I and Level II abilities have been re-interpreted and in fact incorporated successfully within the simultaneous-successive model.)

Das et. al. propose that the simultaneous-successive approach is reasonable when discussing variations in cognitive performance. Verbal and non-verbal processing appear to be associated with successive and simultaneous synthesis respectively, although verbal comprehension may involve both processing modes. There have been speculative attempts also to relate simultaneous and successive processing to memory. Corballis (1969) found two rehearsal strategies, which appear to involve either simultaneous or successive processes, and the act of grouping or "chunking" of information in rehearsal can intuitively be seen as an example of simultaneous processing. Memory per se cannot, however, be reduced to an involvement with only one process. In a study comparing tests of simultaneous-successive processing and tests of a model of hierarchical abilities (Primary Mental Abilities Model), Kirby and Das (1978) found that correlations existed between simultaneous processing and the three PMA factors

(spatial, reasoning, and memory), and to a lesser extent between successive processing and memory. Simultaneous processing was found to be highly correlated with spatial ability especially, and the authors conclude that simultaneous processing involves more than just reasoning ability. Within the context of this study, it was also found that both simultaneous and successive processing play a role in speech and language comprehension, and in memory. It was emphasized that there is no one-to-one correspondence between purported abilities such as memory and reasoning, and the concepts of simultaneous and successive processing as underlying processes.

In summary, the simultaneous-successive approach to human cognitive functioning offers process-oriented insight, as opposed to a power-oriented description, of human information-processing. It becomes obvious from the preceding discussion that much remains to be discovered in terms of the relative effects of the two processing modes in varying tasks. However, the success of this model to date, in accounting for large portions of the variance in factor analytic studies, makes it worthy of further investigation.

Simultaneous-Successive Processing and Development

Within the context of the simultaneous-successive approach, it may be expected that the same type of process would be similarly initiated for a task, independent of the age of subjects performing the task (utilizing as subjects normal children from similar general socio-cultural backgrounds). Molloy (1973) has found this essentially to be the case. In a study involving boys from grades one and four, the three factors of simultaneous, successive and speed were found, and factor structures were very similar for each age group. At the

same time the few disparate loadings are interesting to note and discuss. The "figure-copying subtest" tended to load more on successive processing with the grade one boys, while with the grade fours, the loading was for simultaneous processing. The author felt that for younger children the stimulus may not be seen so much as an integrated whole, and may thus be copied more as a fragmented series. In this instance at least one could speculate that a shift from successive to simultaneous processing may occur developmentally, for certain tasks. In tests of visual short-term memory and memory for design the grade four boys were found to have loadings on successive and simultaneous respectively. In both tasks the younger boys had a greater loading on the speed factor as opposed to the other two. It was felt that in these tasks the younger boys were less able to productively use the stimulus exposure time for the beginnings of processing, and therefore speed became a factor in their responses more than either processing mode. Even these limited results, which overall lend support to the simultaneous-successive approach, provide some indication that the salience of particular modes with respect to particular tasks may change somewhat over development. There are indications that younger children may be more ambivalent about the strategies used for particular tasks, and that successive processing may tend to precede simultaneous processing, even in tasks where simultaneous processing is eventually incorporated as the most efficient mode.

Within Molloy's study, the socio-economic background (SES) of children was found to exert an influence on their preference for simultaneous or successive processing modes at particular ages. Thus in a developmental study of processing, SES should be equivalent

for all age groups being compared. A check for such equivalency is possible through the use of Blishen (1966) ratings.

It has been suggested by Cummins and Das (1977) that simultaneous and successive processing may have different roles for children at varying developmental levels. For certain skills such as reading, successive processing may be involved in the mastery of basic decoding skills, and as such would be a pre-requisite for higher levels of semantic analysis, involving mainly simultaneous processing.

The present examination of information-processing over development provides an opportunity to compare the performance of various age groups on simultaneous and successive tasks per se, and gain information as to the role of each type of synthesis at each stage of development.

Simultaneous-Successive Synthesis and Levels of Processing

Since both the simultaneous-successive and levels of analysis approaches will be examined within the proposed developmental study, it seems important to note that they need not be alien concepts, nor mutually exclusive.

Levels of processing can be conceptualized as falling under the general notion of simultaneous-successive processing. For example, levels of processing tasks to date have largely dealt with verbal stimuli, and the task overall is classified as one dealing with memory performance. The task of relating these two approaches more specifically, and attempting to determine the mode(s) of processing involved with the levels of processing task remains in large part a problem for further research. Indications at this point are that

both modes would contribute in such a task. For example, Das et. al. and Cohen (1973) feel that in general verbal processing tends to be successive, and non-verbal processing tends to be simultaneous, but add that verbal comprehension may involve both modes. This certainly does not add clarity as to which mode may be dominant in a levels of processing task. Additionally, both simultaneous and successive processing have been implicated in rehearsal strategies (Corballis, 1969), which also undoubtedly have effects in the levels of processing task. In a study involving grade four children, Lawson (1976) found that recognition memory following levels of analysis was most closely related to tasks requiring successive processing. Lawson administered marker tests for simultaneous processing, successive processing, and speed of information processing. The factor loadings which resulted were in line with those of previous studies, with recognition memory loading on the successive factor. It must be stressed again that this is not an attempt to relate the levels and information-integration approaches experimentally, but rather the discussion hopefully allows one to come to grips with some possible theoretical relationships between the two.

In levels of analysis theory, the depths to which stimuli are processed have a hierarchical arrangement corresponding to memory performance. However, depth implies more than merely "type of processing" (that is, stimulus salience and meaning), and there is no obvious reason to expect that either simultaneous or successive processing should prevail overall. If rote memory relies on successive processing and reasoning relies on simultaneous, one may hypothesize larger involvement of simultaneous processing for words

processed at a semantic level. As a matter of interest, and possible lead for future research endeavors, a post-hoc comparison of levels of analysis and simultaneous-successive processing modes could be performed. Developmentally, one could also examine shifts in levels of processing results, and check for any possible corresponding shifts in simultaneous-successive processing.

In summary, encoding or information-processing may be undertaken by one of two (or a combination of two) modes of processing. Beyond this method of processing, in verbal memory tasks such as levels of processing, encoding may proceed to either shallow or deep levels, depending on task demands, and this level or depth influences retention level.

Summary of Variables Under Consideration

A recent upsurge of interest in process-based theories of human memory, and cognitive information-processing (Craik & Lockhart, 1972; Das, Kirby & Jarman, 1975) has resulted in research attempts to confirm that retention is due in large part to perceptual encoding (Craik & Tulving, 1975), and also that two general types of cognitive processing underlie all tasks (Kirby & Das, 1978). Though such approaches have enjoyed empirical substantiation in the adult literature, and as such have offered an alternative to the structuralist's view of information-processing, there has been little work done involving the same concepts within a developmental framework. To the extent that such processing becomes altered with increased perceptual and cognitive development, it becomes important to note at what relative stages these alterations occur, and in fact what forms they take.

Overall the present study involves an examination of age-related changes in information-processing, and specifically of processing as it relates to a recent theory of memory. Further clarification is offered by the addition of two varying cognitive "sets". The major purposes of the present study are therefore:

1. To examine developmental changes in memory as indexed by the levels of processing paradigm.

2. To examine the effects of either an incidental or intentional learning set on children's memory, and the manner in which the different learning sets interact with levels of processing.

3. To examine the information-integration model developmentally, and explore the possible relationships of recall following various levels of processing, with the simultaneous-successive dimension.

Chapter III

RATIONALE AND HYPOTHESES

Rationale for Dependent and Independent Variables

Independent variables:

1. Age.

Subject age has obvious significance in a study investigating developmental phenomena. Age levels of 6, 11 and 16 years were generally chosen in accordance with Piaget's "stage" theory of cognitive development (Bee, 1975), and indications of increased perceptual sophistication (Wepman, 1975) and changing attribute preferences (Underwood, 1969) with increasing age. Since the reception of stimuli from the environment, and its subsequent integration within one's cognitive structural framework, are both apparently altered throughout the process of maturation, it is of interest to examine information-processing over several chosen age groups, to discover in more detail when and where, and perhaps why, such differences occur.

2. Levels of processing.

Experimental validation of Craik and Lockhart's (1972) "process-based" theory of memory has been impressive in the adult literature (Craik, 1973; Craik & Tulving, 1975). It is apparent that the perceptual processing involved in encoding a stimulus has an effect upon the retention of that stimulus. Initial evidence provides support for the theory of "depth of processing" in children's memory (Geis & Hall, 1976). In a study designed to examine perceptual encoding, cognitive processing, and memory, within a developmental framework, the levels of processing approach offers a fitting paradigm, since the former processes are subsumed under levels of

processing theory.

3. Learning conditions.

Intentional and incidental learning conditions have been shown to influence retention differentially over varying age groups (Maccoby & Hagan, 1965; Zinchenko, 1962), as well as varying "levels" of processing, within Craik and Lockhart's (1972) framework. In general an incidental paradigm has been favored as providing a more "pure" indication of processing per se (Geis & Hall, 1976). However, as a result of its interactional effects with both age and levels, learning condition provides a method of gaining further insight into the variations both within and between these two variables. In a developmental context, it provides information as to the beneficial (or neutral) effects of intent to learn at various ages, and of the relative effects of intent to learn on varying types of processing, both within and between age levels. The incidental learning groups may still be examined as indicators of "true" information processing, with varying results accountable to levels or age per se, but contrasts with the intentional group provide further insight into the effects of another, imposed, "cognitive" variable.

Dependent variables:

1. Recall.

Recall is a traditional measure utilized to indicate retention, and it has provided a method for differentiating levels of processing within Craik and Lockhart's (1972) framework (Craik, 1973; Geis & Hall, 1976; Moscovitch & Craik, 1976). Recall has also been found to differentiate age groups following "list-learning" tasks (Cole, Frankel

& Sharp, 1971), and to differentiate incidental versus intentional learning conditions (Zinchenko, 1962). Within the present study, since memory performance is of interest as a potential differentiator of age groups, learning conditions, and levels of processing, a measure of retention following the processing task provides an effective vehicle for making such comparisons.

2. Recognition

Like recall, recognition has been incorporated as a measure of retention in studies of levels of processing theory (Craik, 1975; Lawson, 1976). Lawson's study suggested that recognition may produce ceiling effects in older subjects. However, since the present study utilizes subjects down to age six, the recognition task following free recall was included because of the risk of floor effects in recall of the young (Geis & Hall, 1976). Recognition essentially provides an "easier" task, since more cues are provided for retrieval, and results from both recall and recognition may be discussed in terms of theoretical comparisons of the two modes (Kintsch, 1970; Lockhart, Craik & Jacoby, 1975).

3. Reaction Time (RT)

As an additional indicator of "depth" of processing, reaction time has met with only partial success (Craik & Tulving, 1975; Shangi, Das & Mulcahy, 1978). However, reaction time has been implicated as an indicator of speed of information processing, and developmental differences within this context have been found (Surwillo, 1977). There is also speculation that an increased arousal and attentional component, as a result of an intentional learning condition, will result in decreases in reaction time, specifically for 11 and 16 year

olds, who are better able than 6-year olds, to utilize such a cognitive "set" (Zinchenko, 1962). Reaction time provides useful information when one is examining the process involved for decision-making at varying "depths" and when such processing is comparatively analyzed for various ages, and learning conditions. Reaction-time data may be compared with previous studies (Craik & Tulving, 1975) which have attempted to utilize RT as an indicator of depth. It is felt that the contribution of RT within the present study will be related mainly to developmental differences in a "speed of processing" component per se.

4. Simultaneous-Successive Marker Tests

Tasks as markers for simultaneous processing, successive processing, and speed were chosen on the basis of past results, indicating significant loadings on the respective factors (Ashman, 1978; Das, Kirby & Jarman, 1975). In addition, tasks were selected on the basis of difficulty, such that they would be appropriate for the age range utilized within the present study.

Marker tests for each of the two main processing models have been chosen for use when it is not experimentally feasible to administer a large number of tests, and then perform a factor analysis. Through the use of such tests, it is possible to gain indications of the actual salience of the processing modes in the respective tasks. Through correlational examination, it is also possible to test the independence of these factors. In comparative studies, such as those involving differing age groups, it becomes possible to test for an overall preference for one mode of processing, regardless of task. Marker tests include Auditory Serial Recall and Visual Short-Term

Memory for successive synthesis, Figure Copying & Memory for Designs (Graham & Kendall, 1960) for simultaneous, and Color-Naming for speed.

Hypotheses

On the basis of the previous discussion, the following hypotheses were put forward:

Recall Performance

Hypothesis 1

Greater mean recall will result for words processed at the semantic level than for those at the phonemic level, and for those processed at the phonemic level than those at the physical level.

Hypothesis 1.1

Mean recall will be greater for the 16 year olds than the 11 year olds, and greater for the 11 year olds than the six year olds.

Hypothesis 1.2

The 11 and 16 year olds will demonstrate greater mean recall in the intentional, as compared to the incidental learning condition, while 6-year olds will not be differentiated across learning conditions.

Hypothesis 1.3

Increments in mean recall will be greater for words processed to a physical or phonemic level than those processed to a semantic level, in the intentional as opposed to the incidental learning condition.

Hypothesis 1.4

Mean recall for the 6-year olds on physical and phonemic items will be less differentiated from mean semantic recall than it is for the 11 and 16-year olds.

Recognition Performance

Hypothesis 2

Greater overall mean recognition will occur for the 16-year olds over the 11-year olds, and for the 11-year olds over the 6-year olds.

Hypothesis 2.1

Greater mean recognition will occur for words processed at the semantic level over those at the phonemic level, and for those processed at the phonemic level over the physical level.

Hypothesis 2.2

The 11 and 16-year olds will demonstrate greater mean recognition in the intentional, as compared to incidental learning condition, while 6-year olds will not be differentiated across learning conditions.

Hypothesis 2.3

Increases in mean recognition will be greater for words processed to a physical or phonemic level than for those processed to a semantic level, in the intentional learning condition.

Reaction-time Performance

Hypothesis 3

Response latency, as measured by reaction-time, will be positively related to depth of processing.

Hypothesis 3.1

Reaction-time will be shorter in the intentional learning condition, for the 11 and 16-year olds, but will be the same for the 6-year olds over both learning conditions.

Hypothesis 3.2

Reaction time will be less for the 16-year olds than the 11-year olds,

and for the 11-year olds than the 6-year olds.

Simultaneous-Successive Processing

Hypothesis 4

Following factor analysis, loadings on three factors which correspond to the previously-named dimensions of simultaneous synthesis, successive synthesis, and speed are expected at all ages.

Hypothesis 4.1

There will be a shift in the factor loadings for simultaneous marker tests over development, with 6 and 11-year olds having contributions from both simultaneous and successive processing, and 16-year olds having marked loading on only the simultaneous factor.

Simultaneous-Successive Processing and Levels of Analysis

There has been no previous research to suggest a specific relationship between the three levels of processing outlined by Craik and Lockhart (1972), and either simultaneous or successive synthesis as outlined in the information-integration model (Das, Kirby & Jarman, 1975). Based on developmental information, and processing requirements as presented in the previous literature review, it is speculated that, in present results, levels recall will be related to successive processing at ages 6 and 11, and to simultaneous processing at age 16. Within levels of processing, physical and phonemic analyses are expected to be related to successive synthesis, while semantic processing will more likely be tied to simultaneous analysis.

Chapter IV

METHOD

Subjects

Subjects were 150 elementary and high school students from the Public School System in Edmonton, Alberta. Three groups of 50 subjects were chosen, with mean ages of 6.7 (S.D.=.8), 11.4 (S.D.=.9), and 16.9 (S.D.=2.2) years respectively. Within each age group subjects were randomly selected at the given schools. Subjects were of normal intelligence, and of similar socio-economic level as indexed by Blishen (1966) ratings.

Apparatus and Stimuli

Levels of Analysis Task

A Kodak carousel slide projector, mounted with an electro-mechanical shutter, was used to present the visual material in the levels of analysis task. The sequence of onset and duration of slide exposure during a trial continuum was automatically controlled by Hunter Decade Interval Timers. The response apparatus consisted of two push buttons marked "yes" or "no" protruding from a metal box on a table in front of the subject. Response buttons were approximately one centimeter in diameter, and children kept their preferred hand in position in front of the box, and between the two buttons. A subject's button-press response lit up a light in the experimenter's view if it was a "yes" response, indicating the subject's decision for each item.

The stimuli were presented at eye level, on a screen approximately 150 cm. in front of the subject. The experimental stimuli consisted of slide-mounted orienting questions and their related imperative word

stimuli. Orienting questions and imperative words were chosen in terms of their familiarity to subjects at all three ages (Battig & Montague, 1969; Van der Veur, 1975).

Three types of orienting questions were employed. Each type of question was designed to induce the subject to process the imperative word stimulus to one of three "levels", as defined by Craik and Lockhart (1972). To induce "shallow" processing, at a physical or sensory level, the subject was questioned about a physical aspect of the word, e.g. "Does this word start with an s?". Subjects were induced to process at an "intermediate" or phonemic level through questions about the rhyming characteristics of words, e.g. "Does this word rhyme with star?" Processing at a "deep", or semantic level was elicited by questions concerning the meaning of the word stimulus, e.g. "Does this word mean something to play with?". The word stimuli were common nouns, from four to seven letters in length. Each subject received the same 30 questions and words, in the same sequence (Appendix 1.1). Each combination of question type (physical, phonemic, and semantic) and response type (yes and no) appeared five times within a block of 30 trials, and the presentation order of combinations was randomized within the block.

Simultaneous-Successive Task

Two marker tests for simultaneous processing, two for successive processing, and one for the speed factor were administered to all subjects.

Memory for Designs - Graham and Kendall (1960) designed this task to detect minimal brain damage, and it has been used by Das et. al. as

a marker test for simultaneous processing. Each of 15 designs is presented for five seconds using a Kodak carousel projector, and subjects attempt to remember the designs and draw them onto a blank sheet of paper. Each design is scored either 0, 1, 2 or 3 for errors, according to the maintenance of relations and proportions, rather than according to the reproduction of details, as in the manual (See Appendix 1.2 for designs).

Figure Copying - Another task utilized to indicate simultaneous processing, Figure Copying was originally developed by the Gesell Institute (Ilg & Ames, 1964). Booklets are designed for the task such that 12 figures are presented, one at a time, with a space beside each into which the subject is to copy the design. Special booklets are designed with the figures on the right-hand side of the page, such that left-handed subjects do not cover the design as they work. Each drawing is scored as 0, 1 or 2 according to the maintenance of geometric relations and proportions (See Appendix 1.3 for designs and scoring). Ashman deleted six of the easier figures on the original task, added six from the Developmental Test of Visual Motor Integration (Beery, 1967), and devised the two most difficult figures himself.

Visual Short-Term Memory (VSTM) - Subjects are presented with eighteen five-digit grids, following two examples, using a Kodak carousel projector. Each grid is presented for 10 seconds, following which subjects are to name aloud colours indicated on a projected chart, for five seconds. Following this filler task, they are requested to fill in as many digits as they can recall on an empty grid. Total score consists of the number of digits correctly recalled. This is a

marker for successive processing (See Appendix 1.4 for sample grids).

Auditory Serial Recall - This marker test for successive processing was also revised from its original format by Ashman (1978). The task consists of sixteen lists of words, eight acoustically similar and eight unrelated, beginning with a list of four words and progressing up to seven-word lists (See Appendix 1.5 for this test). Each series of words is read to the subject at the rate of approximately one word per second, and the subject repeats as many of the words, in order, as he/she can. The score consists of the number of words recalled in the correct serial order.

Color-Naming - This task (Stroop, 1935) tends to load on the speed factor. Subjects are presented with a chart, approximately 100 cm. x 50 cm., upon which strips of five basic colours are randomly arranged in eight rows of five strips per row. Subjects stand approximately 250 cm. away from the chart, which is initially facing towards the wall. When the chart is turned around, subjects name the colours, from left to right, and through rows one to eight. The score is the subject's time to complete the task, recorded in milliseconds.

Procedure

All subjects were tested individually, in a small room at their respective schools. Subjects were seated at a table facing the screen, with the button-press response box on the table. The experimenter sat at another table, with the projector located on a stand between the subject and experimenter. Subjects each used their preferred hand for button-press responses.

Subjects at each age were randomly placed in either an incidental or intentional learning condition. The incidental group were told that they would be asked some questions about words, and were encouraged to answer carefully and quickly. In addition, the intentional group were told they would be asked to recall the stimulus words, and asked to think to themselves about ways they could help themselves remember.

A trial continuum began with the presentation of the orienting question for five seconds. This was followed by a six second interval and the presentation of the imperative word for two seconds. Subjects then responded, and there was an interval of from eight to ten seconds prior to the appearance of the next question.

Six practise trials, including each possible combination of the three question types and two response types, were administered prior to the 30 experimental trials. At the end of the trials, each subject was given up to three minutes for free verbal recall of the stimulus words. A recognition task then followed, in which subjects were read a randomly ordered list of 30 stimulus words and 30 distractor words, and asked to identify the former with a yes or no verbal response. Since recognition was incorporated into the task only after results for the initial 18 subjects suggested a possible floor effect for the younger children for recall, recognition scores were obtained for 32 children at each age, and not 50.

Following the levels task, the Color-Naming and Auditory Serial Recall tasks were administered, individually and in alternating order, to subjects at each age. Test administration proceeded for each task as described in the previous section. Memory for Designs, Figure Copying and VSTM were administered to subgroups of from four to six

children at each age, at another time but within three days of the initial testing. Order of presentation of the latter three tests was randomized for each subgroup. All testing was carried out in a small room within the subject's school. Total testing time for each child was approximately one hour; half an hour for each of the two sessions. The younger children were tested whenever possible during the morning, with the 11 and 16-year olds being tested whenever they were available throughout the day.

Chapter V

RESULTS

The results of this study will be presented in four sections. The first two will deal with the results of recall and recognition, with respect to the levels of analysis task. The reaction-time results for the levels task will be summarized in the third section. The fourth section will include the experimental results for the simultaneous-successive marker tests, and exploratory analyses of the contributions of each type of synthesis to recall over development.

Levels of Analysis

Recall

Total recall was calculated for each subject, as was the number of words recalled for each level. Means and standard deviations of recall at each age are presented in Table 1. Recall results across the three age groups, two learning conditions, and three levels, were compared using a 3 x 2 x 3 analysis of variance, with repeated measures for the levels factor (Table 2).

Significant main effects for age ($F_{2,144} = 51.79$, $p<.001$), and learning condition ($F_{1,144} = 11.51$, $p<.001$) were obtained. A significant age x learning condition interaction ($F_{2,144} = 4.71$, $p<.05$) was also found, and is depicted graphically in Figure 1. Tukey (a) tests (Winer, 1962) of the means in this interaction show that there is no effect of learning condition at the six year old level, but that intentional learning produces higher recall than incidental learning at both age 11 ($F_{1,144} = 12.08$, $p<.001$) and age 16 ($F_{1,144} = 51.77$, $p<.001$).

A significant main effect was obtained for levels of processing

Table 1

Means and Standard Deviations for Recall

Data at Three Age Levels

(N=150)

Source	Mean	s.d.
Physical processing		
Age 6	.680	1.028
Age 11	1.260	1.426
Age 16	1.460	1.615
Phonemic processing		
Age 6	.840	.902
Age 11	2.480	1.565
Age 16	2.640	1.694
Semantic processing		
Age 6	1.660	1.243
Age 11	4.400	1.939
Age 16	4.740	1.467

Table 2

ANOVA for Recall Data
Involving 3(Ages) x 2(Learning Conditions) x 3(Levels)
(N=150)

Source	df	MS	F
Between			
B_1(Age)	2/144	158.69	51.78**
B_2(Learning Condition)	1/144	35.28	11.51**
Error	144	3.06	
Within			
W_1(Levels)	2/288	235.39	149.21**
Error	288	1.58	
B_1 x B_2	2/144	14.42	4.71*
B_1 x W_1	4/288	20.86	13.23**
B_2 x W_1	2/288	.08	.051
B_1 x B2 x W_1	4/288	1.15	.729

*p<.01

**p<.001

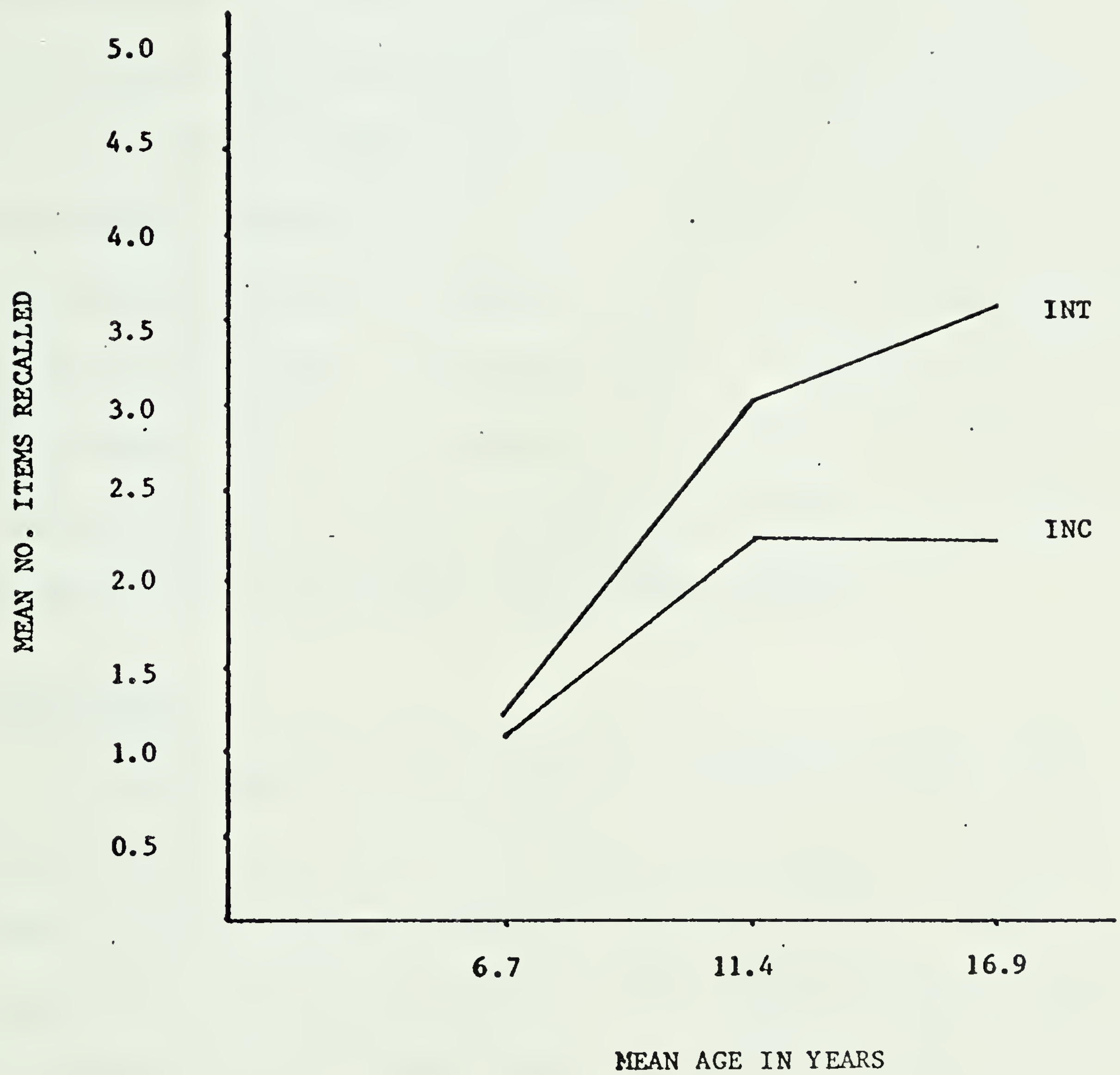


FIGURE 1. The mean recall of children at ages 6.7, 11.4, and 16.9 under two types of learning condition, collapsed over levels.
INT=Intentional; INC=Incidental. (N=150)

($F_{2,228}$ = 149.21, p<.001), and there was also a significant levels x age interaction ($F_{4,288}$ = 13.23, p<.001) which is depicted graphically in Figure 2. Multiple comparisons of the means involved in this interaction were performed using the Tukey (a) procedure. Results indicated that, at the physical level, recall for six year olds was less than that of 16-year olds. At both the phonemic and semantic levels, the 11 and 16-year olds had recall scores superior to those of the six year olds, but at no level did their scores differ significantly from one another. Additionally, subjects at age six had differences in mean recall between the phonemic and semantic levels, but no differences between physical and phonemic processing results. At ages 11 and 16 there were significant differences between all three levels, with semantic processing resulting in better recall than phonemic, and phonemic processing producing higher recall than physical.

<u>Recognition</u>

It was decided on the basis of preliminary results that recall following the levels of analysis task may result in a floor effect for subjects at the six, and perhaps eleven year level. Therefore a recognition task was incorporated, and results for this task are based on 32 subjects at each age, rather than 50 at each age as for recall.

Recognition results across the three age groups, two learning conditions, and three levels were analyzed using a 3 x 2 x 3 factorial design (Table 3). Significant main effects were found for age ($F_{2,90}$ = 6.27, p<.01), and level of processing ($F_{2,180}$ = 95.61, p<.001). There was also an age x levels interaction. The means and standard deviations involved here are presented in Table 4. The means are also

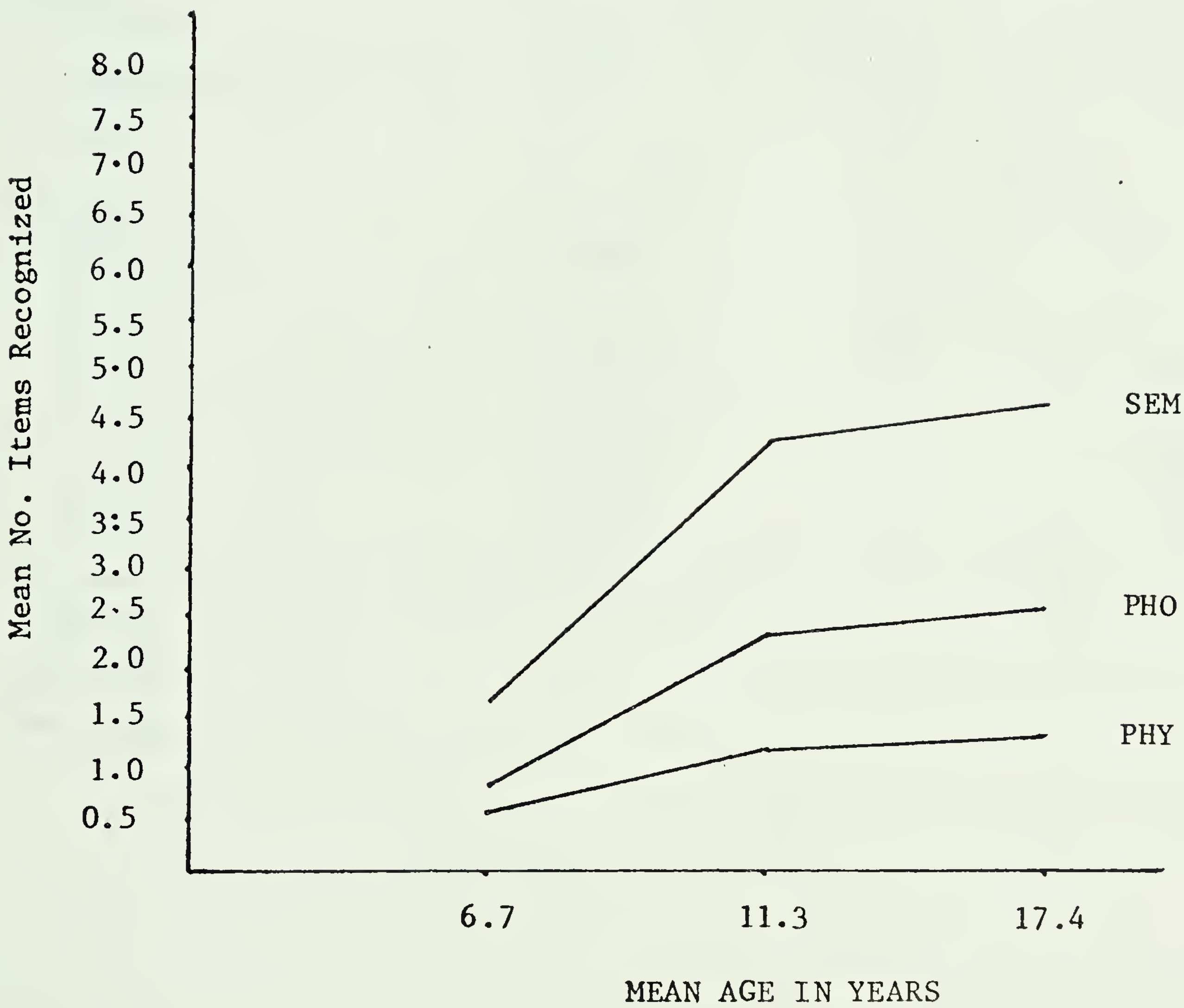


FIGURE 2. The mean recall of children at average ages 6.7, 11.3, and 17.4 years, following processing at three levels. PHY=physical; PHO=phonemic; SEM=semantic. (N=150)

Table 3

ANOVA for Recognition Data
Involving 3(Ages) x 2(Learning Conditions) x 3(Levels)
(N=96)

Source	df	MS	F
Between			
B_1(Age)	2/90	35.17	6.27**
B_2(Learning Condition)	1/90	20.06	3.58
Error	90	5.61	
Within			
W_1(Levels)	1/180	209.90	95.61***
Error	180	2.20	
$B_1 \times B_2$	2/90	7.96	1.42
$B_1 \times W_1$	4/180	6.15	2.80*
$B_2 \times W_1$	2/180	3.67	1.67
$B_1 \times B_2 \times W_1$	4/180	2.61	1.188

*$p<.05$
**$p<.005$
***$p<.001$

Table 4

Means and Standard Deviations for Recognition Data at Three Age Levels

(N=96)

Source	Mean	s.d.
Physical processing		
Age 6	4.094	1.444
Age 11	3.656	2.145
Age 17	4.875	2.342
Phonemic Processing		
Age 6	5.125	2.161
Age 11	6.375	1.781
Age 17	6.906	1.568
Semantic processing		
Age 6	6.594	1.656
Age 11	7.125	1.474
Age 17	7.625	1.556

graphically depicted in Figure 3. Multiple comparisons of the means were performed using the Tukey (a) procedure. At all three age levels it was found that semantic recognition was greater than phonemic, and phonemic recognition was greater than physical. There were no differences in semantic recognition for children at six, 11 and 17 years. Recognition of physical items was greater at age 17 than at ages 11 and six, with the latter two groups not differing. Phonemic recognition was greater for 17 and 11 year olds than for six year olds, but did not differentiate the former groups.

Reaction Time

Reaction-time in milliseconds was recorded for each subject during every trial on the levels of analysis task. Reaction-time results across the three age groups, two learning conditions, and three levels were compared using a 3 x 2 x 3 analysis of variance, with repeated measures for the levels factor (Table 5).

Significant main effects for age ($F_{4,22} = 251.21$, $p<.001$) and levels ($F_{2,228} = 59.08$, $p<.001$) were obtained. In addition, there were significant interactions for age x levels ($F_{4,288} = 14.07$, $p<.001$) and for age x learning condition x levels ($F_{4,288} = 4.155$, $p<.01$). Means involved in the latter interaction are presented graphically in Figure 4.

Multiple comparisons of the means of the three-way interaction were performed using the Tukey (a) procedure. Differences in RT were found over age, such that 16 year olds responded more quickly than 11 year olds, and 11 year olds responded more quickly than six year olds. At six years of age, RT differentiated all three levels of analysis, with semantic responses having longer RT's than phonemic,

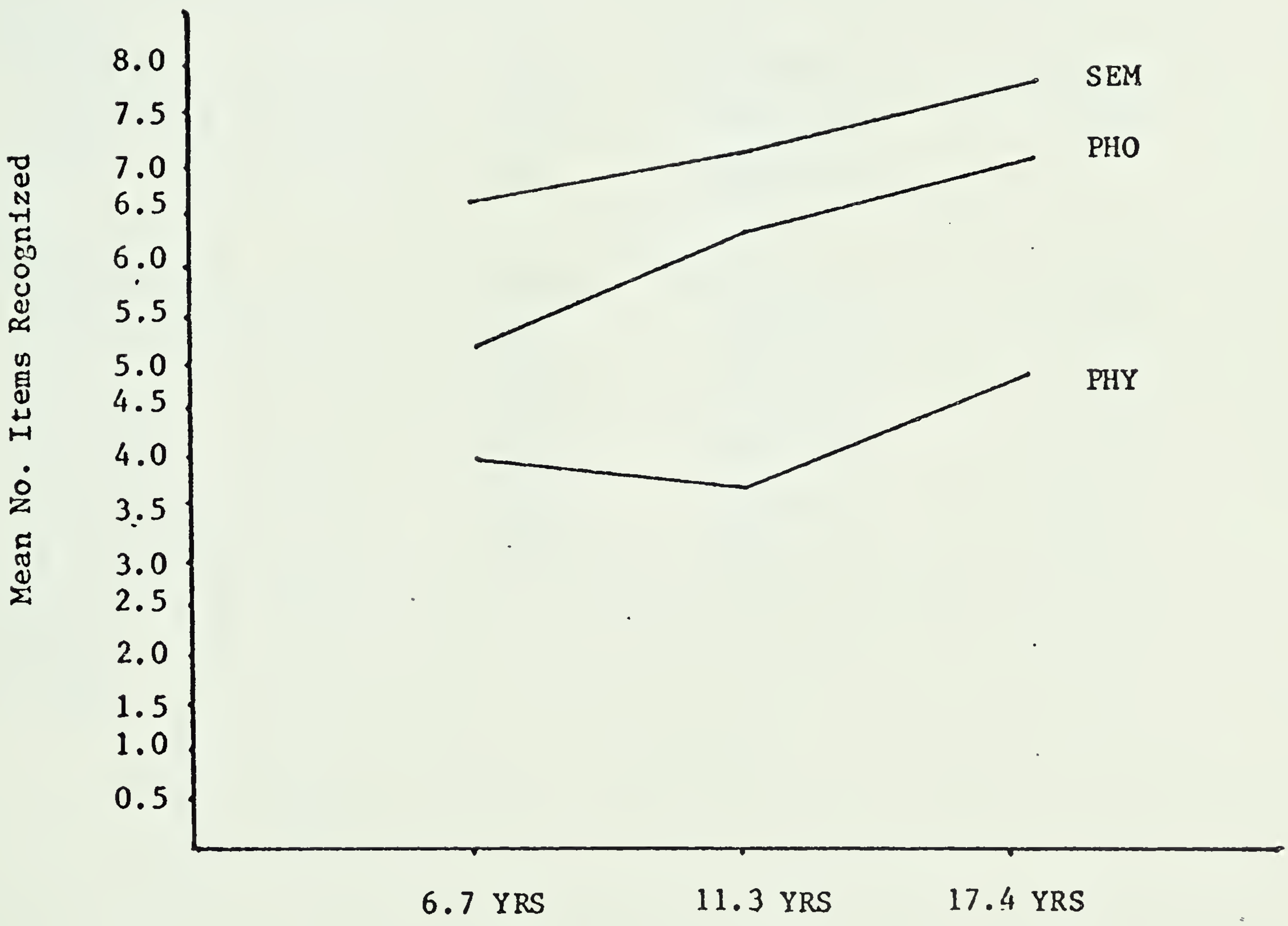


FIGURE 3. The mean recognition of children at ages 6.7, 11.3 and 17.
years at three levels of processing.
PHY=physical; PHO=phonemic; SEM=semantic. (N= 96)

Table 5

ANOVA for Reaction-Time Data

Involving 3(Ages) x 2(Learning Conditions) x 3(Levels)

(N=150)

Source			
Between			
B_1(Age)	2/144	87935798.17	251.21**
B_2(Learning Condition)	1/144	512139.47	1.46
Error	144	350054.01	
Within			
W_1(Levels)	2/288	1821886.13	59.08**
Error	288	30838.99	
B_1 x B_2	2/144	174878.80	.50
B_1 x W_1	4/288	433737.88	14.07**
B_2 x W_1	2/288	79553.71	2.58
B_1 x B_2 x W_1	4/288	128149.03	4.155*

*p<.01

**p<.001

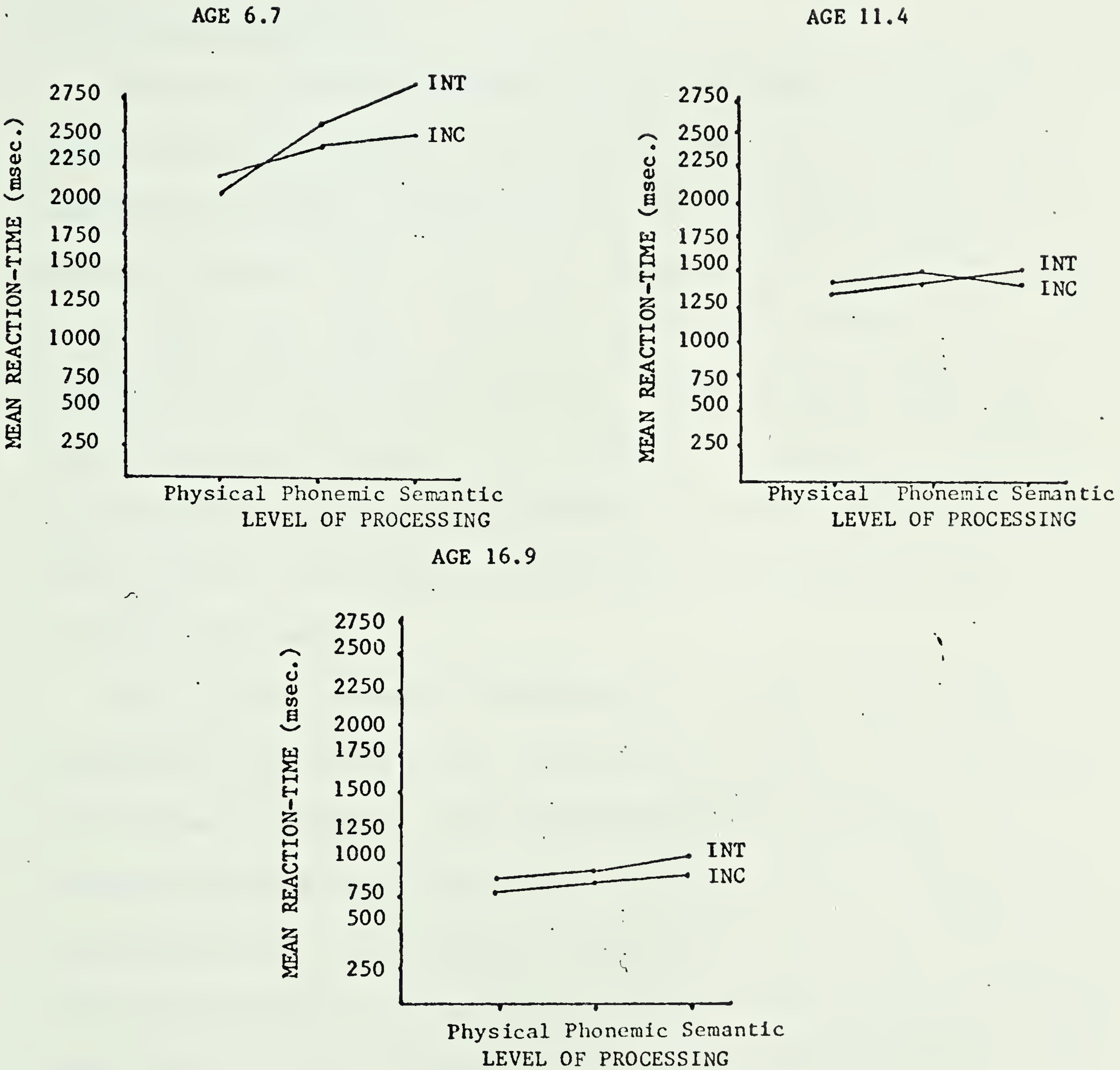


FIGURE 4. The mean reaction-time of children at three levels of processing, and under two learning conditions. INT = Intentional; INC = Incidental

and phonemic responses having longer RT's than physical. At ages 11 and 16, only the semantic and physical RT's were different, with semantic responses having longer RT's. There were no significant differences found for RT over different learning conditions.

Simultaneous Successive

Results on the Color-Naming test, a marker test for the speed factor, were not included in the final analyses of simultaneous and successive processing. Although initial factor analyses indicated that Color-Naming indeed loaded on a separate factor at all three ages, it was less clear at age 16, and also when recall measures were included as part of a factor analysis. Since the speed factor was indexed using only one task, its' validity was somewhat in question, and since the major factors of interest were simultaneous and successive processing, the latter two are utilized exclusively in the following discussion.

The means and standard deviations for the four simultaneous-successive tests, at each age, can be seen in Table 6, and their intercorrelations in Table 7. These correlations were submitted to a principal components analysis, and the two factors whose eigenvalues were greater than 1.0 were rotated according to a Varimax criterion at ages six and eleven. At age sixteen only one factor had an eigenvalue greater than 1.0, and the second factor for rotation was chosen since it had an eigenvalue greater than 0.9. Results of the analysis are presented in Table 8.

With the exception of a somewhat ambivalent breakdown for the Memory for Designs task at age sixteen, loadings for simultaneous and

Table 6

Means and Standard Deviations of
Four Simultaneous-Successive Tests

Variable	Age 6.7(N=50)		Age 11.4(N=50)		Age 16.9(N=50)	
	Mean	s.d.	Mean	s.d.	Mean	s.d.
Memory for Designs	10.58	4.67	2.46	2.74	1.02	1.21
Figure Copying	4.08	2.88	11.74	5.30	20.10	2.47
Visual Short-Term Memory	30.32	8.62	64.40	11.64	78.06	8.96
Auditory Serial Recall	40.96	9.91	58.28	8.77	66.24	7.08

Table 7

Intercorrelations of Simultaneous-Successive Tests

Variable	Age 6.7 (N=50)				Age 11.4 (N=50)				Age 16.9 (N=50)			
	MFD	FC	VSTM	ASR	MFD	FC	VSTM	ASR	MFD	FC	VSTM	ARS
Memory for Designs (MFD)	1.000				1.000				1.000			
Figure Copying (FC)	<u>-0.474</u>	1.000			-0.236	1.000			<u>-0.356</u>	1.000		
Visual Short-Term Memory (VSTM)	-0.117	0.155	1.000		-0.082	-0.098	1.000		-0.146	0.144	1.000	
Auditory Serial Recall (ASR)	-0.125	0.250	<u>0.306</u>	1.000	-0.062	-0.085	0.174	1.000	<u>-0.405</u>	0.078	0.198	1.000

<u>Underlined correlations</u> $p<.05$

Table 8

Principal Components Analysis with Varimax Rotation of Simultaneous-Successive Tests

	Age 6.7 (N=50)			Age 11.4 (N=50)			Age 16.9 (N=50)		
	Factor			Factor			Factor		
	Simultaneous	Successive	h^2	Simultaneous	Successive	h^2	Simultaneous	Successive	h^2
Memory for Designs	-870	-014	757	795	-249	694	-671	-470	670
Figure Copying	832	193	729	-777	-271	677	914	-063	840
Visual Short-Term Memory	032	818	670	-003	751	564	028	651	425
Auditory Serial Recall	157	783	683	012	729	532	124	823	692
Variance	1.474	1.319		1.236	1.231		1.325	1.302	
% of Total Variance	36.85	32.98		30.91	30.78		33.13	32.56	

* Decimals omitted from factor loadings

successive synthesis as presented in Table 8 conform closely to the pattern established in previous research (Das, Kirby & Jarman, 1975).

Simultaneous-Successive Processing and Levels of Analysis

Exploratory analyses were carried out to determine whether successive and simultaneous processing are related to recall memory, and whether this relationship differs over development or for material processed to different levels.

Initially, correlational matrices involving recall results at each of the three levels of analysis, and results for the four simultaneous-successive marker tests, were obtained for subjects under both the incidental and intentional learning conditions at each age (Table 9, 10 and 11). Correlations between the simultaneous-successive battery, and both physical and semantic recall were similar under both learning conditions at all age levels, and the results over learning conditions were combined in subsequent analyses. Since phonemic recall tended to change affiliation in terms of its correlates under the two learning conditions, there was no justification for combining the results with the implication that they represent a homogeneous group, and further comparisons utilizing phonemic recall were not undertaken.

The intercorrelations of the simultaneous-successive marker tests and the recall results following physical and semantic processing (Table 12) were submitted to a principal components analysis, and three factors at each age were rotated according to a Varimax criterion. At ages 11 and 16 these three factors corresponded to those having eigenvalues greater than 1.0, and at age six they corresponded to two

Table 9

Intercorrelations of Simultaneous-Successive Tasks
and Levels of Analysis Recall at Age 6

(N=50)

Variables	Age 6.7 (Incidental)						
	PR	PhR	SR	MD	FC	VSTM	ASR
Physical Recall (PR)	1.000						
Phonemic Recall (PhR)	-.214	1.000					
Semantic Recall (SR)	.215	.224	1.000				
Memory for Designs (MFD)	<u>.351</u>	-.172	-.204	1.000			
Figure Copying (FC)	.013	.017	.136	-<u>.514</u>	1.000		
Visual Short-Term Memory (VSTM)	-.076	.059	<u>.408</u>	-.195	-.101	1.000	
Auditory Serial Recall (ASR)	.169	.027	.227	-.251	.218	<u>.426</u>	1.000
	Age 6.7 (Intentional)						
	PR	PhR	SR	MD	FC	VSTM	ASR
Physical Recall (PR)	1.000						
Phonemic Recall (PhR)	.203	1.000					
Semantic Recall (SR)	.293	.290	1.000				
Memory for Designs (MFD)	-.009	.024	.078	1.000			
Figure Copying (FC)	-.139	-.050	.100	-<u>.302</u>	1.000		
Visual Short Term Memory (VSTM)	.037	.255	<u>.345</u>	.145	<u>.406</u>	1.000	
Auditory Serial Recall (ASR)	.021	.008	.255	.263	<u>.390</u>	<u>.418</u>	1.000

<u>underlined correlations</u> $p<.05$

Table 10

Intercorrelations of Simultaneous-Successive Tasks
and Levels of Analysis Recall at Age 11

(N=50)

Variables	PR	PhR	SR	MD	FC	VSTM	ASR
Age 11.4 (Incidental)							
Physical Recall (PR)	1.000						
Phonemic Recall (PhR)	.485	1.000					
Semantic Recall (SR)	.640	.450	1.000				
Memory for Designs (MFD)	-.256	-.131	-.194	1.000			
Figure Copying (FC)	.220	.365	.416	-.033	1.000		
Visual Short-Term Memory (VSTM)	.170	.325	.483	.039	.483	1.000	
Auditory Serial Recall (ASR)	.096	.245	.408	.175	.263	.612	1.000
Age 11.4 (Intentional)							
Physical Recall (PR)	1.000						
Phonemic Recall (PhR)	.117	1.000					
Semantic Recall (SR)	.167	-.033	1.000				
Memory for Designs (MD)	-.038	.317	-.030	1.000			
Figure Copying (FC)	-.229	.118	.226	-.241	1.000		
Visual Short-Term Memory (VSTM)	.181	.196	.610	.108	.123	1.000	
Auditory Serial Recall (ASR)	.150	.136	.591	.027	.257	.708	1.000

underlined correlations $p<.05$

Table 11

Intercorrelations of Simultaneous-Successive Tasks and Levels of Analysis Recall at Age 16

(N=50)

Variables	PR	PhR	SR	MD	FC	VSTM	ASR
Age 16.9 (Incidental)							
Physical Recall (PR)	1.000						
Phonemic Recall (PhR)	.007	1.000					
Semantic Recall (SR)	-.535	.083	1.000				
Memory for Designs (MFD)	-.071	.635	-.025	1.000			
Figure Copying (FC)	-.035	-.479	.185	-.383	1.000		
Visual Short-Term Memory (VSTM)	-.017	.038	.112	.019	.221	1.000	
Auditory Serial Recall (ASR)	.313	-.291	-.009	-.432	.285	.307	1.000
Age 16.9 (Intentional)							
Physical Recall (PR)	1.000						
Phonemic Recall (PhR)	.437	1.000					
Semantic Recall (SR)	.470	.457	1.000				
Memory for Designs (MFD)	.299	-.135	-.088	1.000			
Figure Copying (FC)	-.230	-.038	.203	-.419	1.000		
Visual Short-Term Memory (VSTM)	.055	.207	.319	-.344	.162	1.000	
Auditory Serial Recall (ASR)	-.006	.020	-.061	-.436	-.242	.103	1.000

underlined correlations $p<.05$

Table 12

Intercorrelations of Simultaneous-Successive and Recall Results

(Intentional and Incidental Groups Combined)

Variable	Age 6.7 (N=50)						Age 11.4 (N=50)						Age 16.9 (N=50)					
	PR	SR	MfD	FC	VSTM	ASR	PR	SR	MfD	FC	VSTM	ASR	PR	SR	MfD	FC	VSTM	ASR
Physical Recall (PR)	1.000						1.000						1.000					
Semantic Recall (SR)	0.234	1.000					$\underline{0.389}$	1.000					$\underline{0.363}$	1.000				
Memory for Designs (MFD)	0.138	-0.142	1.000				-0.199	-0.238	1.000				0.098	-0.042	1.000			
Figure Copying (FC)	-0.106	0.080	$\underline{-0.474}$	1.000			-0.107	0.199	-0.236	1.000			-0.002	$\underline{0.317}$	$\underline{-0.356}$	1.000		
Visual-Short Term Memory (VSTM)	-0.045	$\underline{0.311}$	-0.117	0.155	1.000		0.066	$\underline{0.355}$	-0.082	-0.098	1.000		-0.014	0.182	-0.146	0.144	1.000	
Auditory Serial Recall (ASR)	0.038	0.168	-0.125	0.250	$\underline{0.306}$	1.000	-0.009	$\underline{0.309}$	-0.062	-0.085	0.194	1.000	0.090	-0.004	$\underline{-0.405}$	0.078	0.198	1.000

underlined correlations p<.05

factors having eigenvalues greater than 1.0, and a third factor having an eigenvalue of .953. Results of the analysis are presented in Table 13.

Besides the factors of simultaneous and successive synthesis, a third factor emerged at each age. Both retention measures consistently loaded on this factor, and it was therefore referred to as a "memory" factor. In addition, at ages six and eleven, semantic recall was found to load with successive processing. A type of shift seems to occur between the samples at ages 11 and 16, since semantic recall has a moderate loading on the simultaneous factor at age 11, and it has loadings only on the memory and simultaneous factors at age 16. Physical recall loaded only on the memory factor, at all three ages.

Median-Split Results

Based on the factor loadings from the original factor analysis involving simultaneous and successive processing, and raw scores of the marker tests, factor scores for each of the two modes were obtained for all subjects. A "Median-split" technique was used to group subjects at each age depending upon whether their factor scores were "high" for both modes, "low" for both modes, high simultaneous-low successive, or high successive-low simultaneous. Two-way analyses of variance were then performed for physical recall and semantic recall at each age, utilizing the cell frequencies found following the median-split (Table 14).

Two-way analyses of variance, involving high or low factor scores for each of simultaneous and successive synthesis, indicated that there were no differences in either physical or semantic recall related to

Table 13

Principal Components Analysis With Varimax Rotation of Simultaneous-Successive Tasks and Recall Results

	Age 6.7 (N=50)				Age 11.4 (N=50)				Age 16.7 (N=50)			
	Factor				Factor				Factor			
	Sim	Succ	Mem	h^2	Sim	Succ	Mem	h^2	Sim	Succ	Mem	h^2
Physical Recall	142	-139	868	792	-014	008	937	879	-108	067	891	811
Semantic Recall	-142	406	680	647	374	610	468	731	565	-040	672	773
Memory for Designs	871	-035	-006	760	-643	-074	-344	538	-388	-693	244	690
Figure Copying	-825	166	-046	711	878	-095	-212	824	875	140	-029	785
Visual Short-Term Memory	-023	848	030	721	-069	696	140	509	278	411	121	260
Auditory Serial Recall	-156	704	044	522	-016	779	-151	629	-153	898	096	838
Variance	1.505	1.428	1.220		1.477	1.329	1.303		1.481	1.347	1.331	
% of Total Variance	25.09	23.80	20.33		24.62	22.15	21.72		24.68	22.44	22.18	

* Decimals omitted from factor loadings.

Table 14

Cell Frequencies for ANOVA Following a Median-Split of Simultaneous-Successive Factor Scores

(N=150)

Age	High Simultaneous High Successive	High Successive Low Simultaneous	High Simultaneous Low Successive	Low Simultaneous Low Successive
6.7	15	10	10	15
11.4	11	14	14	11
16.9	10	15	15	10

factor scores for subjects at mean age 6.7 (Appendices 2.1 and 2.2).

Similar two-way analyses for subjects at mean age 11.4 indicated a significant simultaneous x successive interaction for physical recall (Appendix 2.3). The latter interaction is presented graphically in Figure 5, and it is evident that 11 year olds with high simultaneous-low successive factor scores recall more physically processed words than those with any other combination of factor scores.

For semantic recall with 11 year olds, utilizing the same 2 x 2 ANOVA format, main effects for both simultaneous and successive processing were obtained (Appendix 2.4). At mean age 11.4, high simultaneous factor scores relate to higher semantic recall than do low simultaneous scores, whereas high successive factor scores relate to lower semantic recall than do low successive scores. This information is presented graphically in Figure 6.

At mean age 16.9 there was no relationship found between physical recall and factor scores for simultaneous-successive processing, following the 2 x 2 ANOVA (Appendix 2.5).

For semantic recall at mean age 16.9, results of the 2 x 2 ANOVA indicated a main effect for simultaneous factor scores, and no other significant effects (Appendix 2.6). The degree of semantic recall is positively related to one's factor scores for simultaneous processing, as depicted in Figure 7.

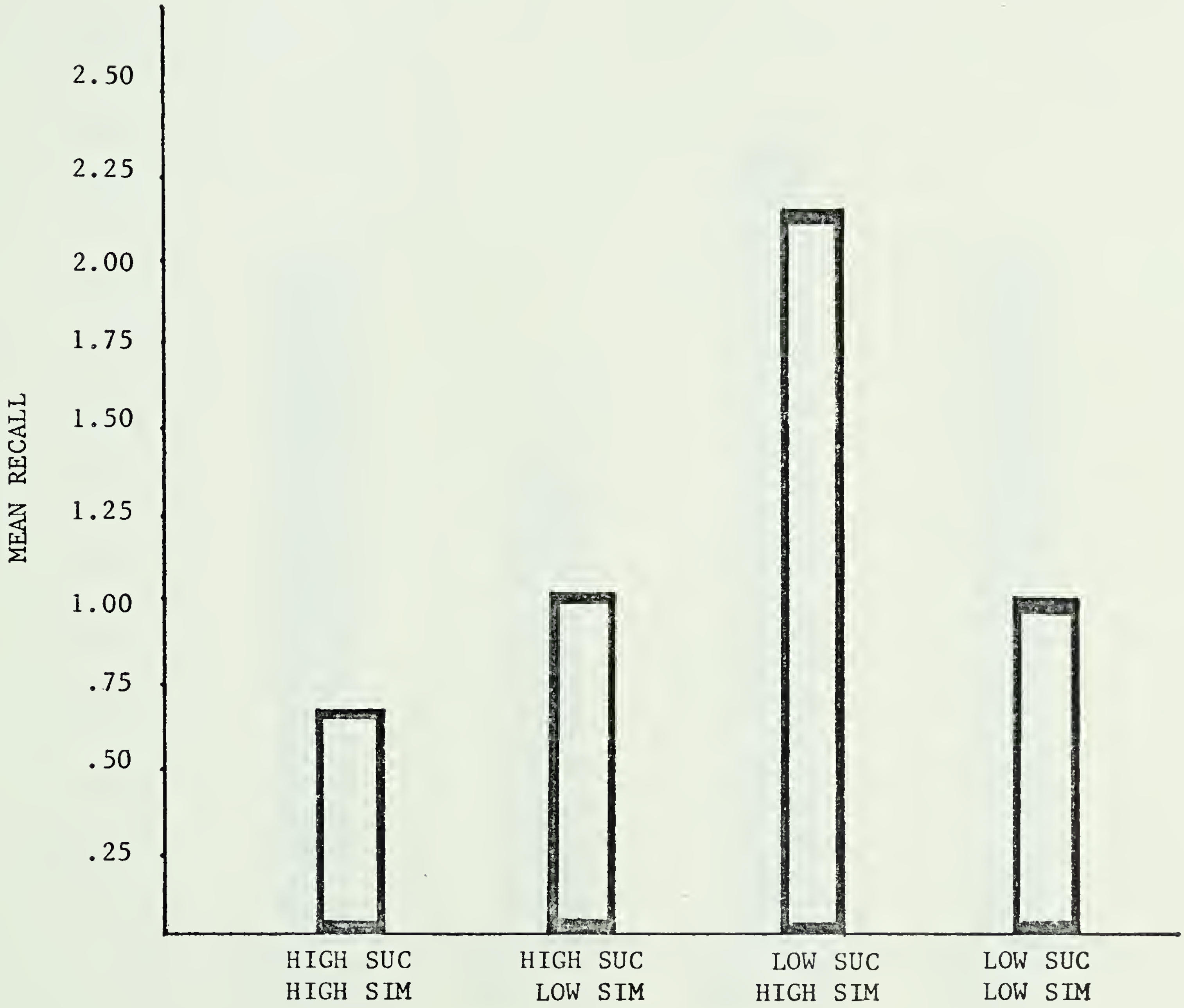


FIGURE 5. The mean physical recall of children at average age 11.4, grouped on the basis of high or low factor scores on successive (SUC) or simultaneous (SIM) processing.

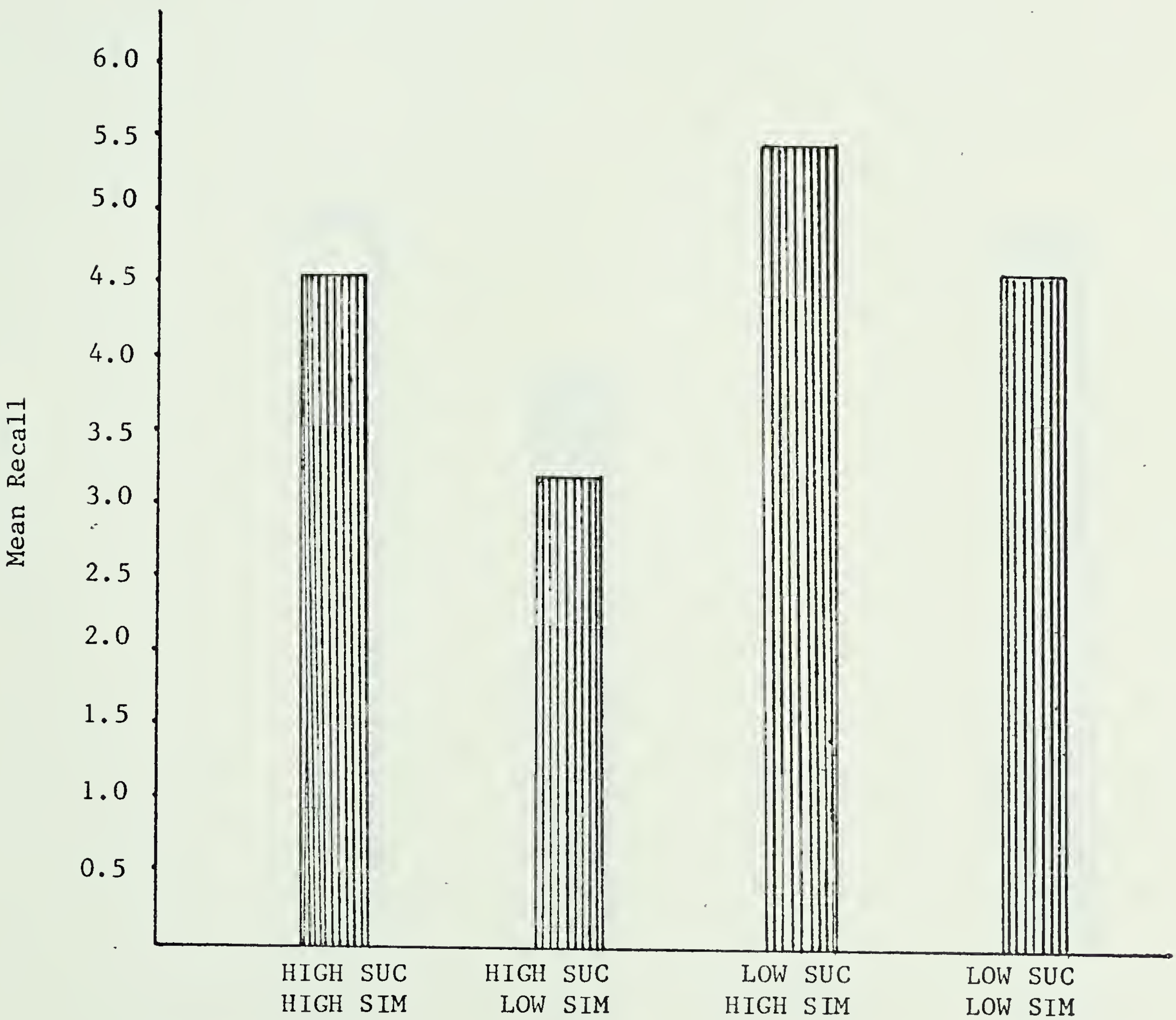


FIGURE 6. The mean semantic recall of children at average age 11.4, grouped on the basis of high or low factor scores on successive (SUC) or simultaneous (SIM) processing.

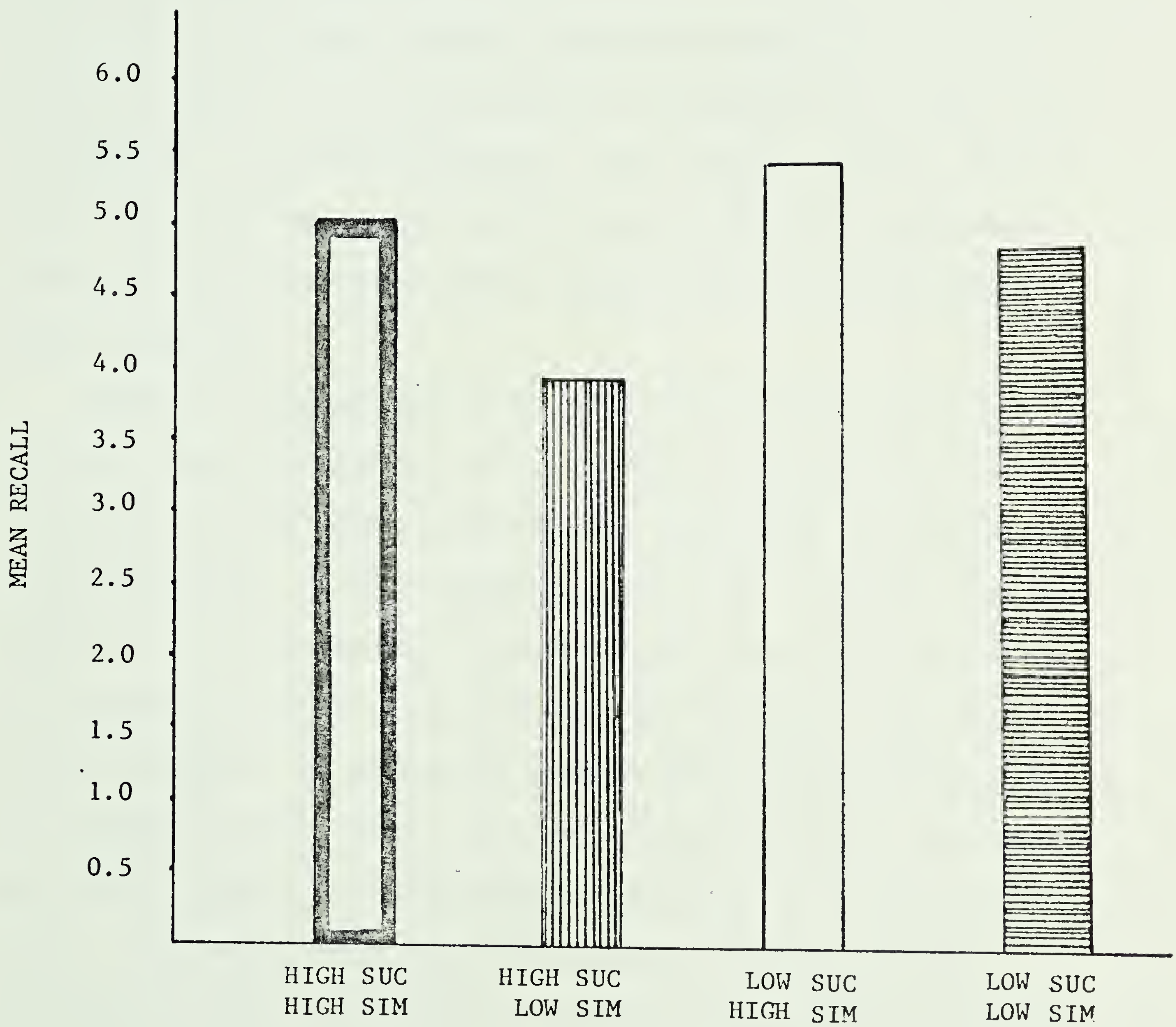


FIGURE 7. The mean semantic recall of children at age 16.9, grouped on the basis of high or low factor scores on successive (SUC) or simultaneous (SIM) processing.

Chapter VI

DISCUSSION

Recall

Recall results supported Hypothesis 1 in that the postulated effect of "depth" of processing occurred within a developmental context. Overall, material processed to deeper levels was better retained. In the 16 and 11 year olds, semantic processing produced better recall than did phonemic, and phonemic processing produced better recall than did physical. As in Geis and Hall's (1976) results, based on children ages seven to eleven, recall for the youngest group did not differentiate physical and phonemic items, though semantic items retained their superiority.

Within the Geis and Hall study, utilizing children from grades one to five, recall differences were found between semantically encoded items and all other items, while physical and phonemic processing were undifferentiated. In their paradigm, subjects were presented with the stimulus word, both visually and auditorially, before they were asked the orienting question. They were also given unlimited time within which to respond. In the present study children were presented with the orienting question first, and then the imperative word stimulus, and they were asked to respond with a button-press as quickly as possible. Both visual and auditory presentations were used for the questions and words. The cognitive demands placed upon the subject by these two experimental designs are quite different. Geis and Hall's subjects had the imperative words in mind, and may therefore have analyzed them to deeper levels than those required by the respective

orienting questions, even before the questions were presented. When words were already being practised, or rehearsed to some extent, the physical and phonemic questions may have added to the strength of memory traces only in a weak and undifferentiated manner. However, the response to a semantic question, as indicated by their results, may have provided elaboration beyond the extent of any initial efforts, such that these imperative words would be remembered better. In the present experimental task, subjects were able to engage in little processing of the imperative words beyond that required to respond to the preceding orienting question especially since speed of response was encouraged. Under these conditions, and with age groups similar to those of Geis and Hall, the effect of levels of analysis per se became evident in recall results. It would appear that the more demanding reaction-time task provides a paradigm within which three levels of analysis can be more clearly defined. The fact that six year old recall was not differentiated for physical and phonemic words in the present study is likely a function of task difficulty, and the difficulty of recall as a mode of retention. At this age, it is possible that the task of remembering the orienting questions, and producing the yes or no button-press response, took much of the children's attention, and that their performance in recall was uniformly low without the benefit of the deepest, semantic level of analysis. This notion receives support from the recognition data for six year olds, to be discussed in the next section. In recognition the children were provided with cues in the form of the stimulus words, and the easier task resulted in a superiority of phonemic over physical words.

Hypothesis 1.1 received partial support from present results.

In recall, the 16 year olds performed better than the six year olds at all levels, and the 11 year olds were superior to the six year olds in phonemic and semantic recall. It is speculated that both difficulty of the experimental task and the response task may have contributed to the performance of the six year olds, though a case will be made for age effects over and above these factors when recognition results are presented. Both the 16 and 11 year olds performed equally well on the recall of words which had been processed to the deeper phonemic and semantic levels, while the 11 year olds recalled only as well as the six year olds for physically processed words.

It appears that recall may indeed be partially a result of the interaction between level of analysis, and one's degree of cognitive sophistication, as indexed by chronological age. There have been recent suggestions that the effects of levels of analysis are tempered by other environmental or task variables (Jacoby, Bartz & Evans, 1978; Moscovitch & Craik, 1976). This notion will be discussed further in a later section.

Though Geis and Hall found no differences in recall for subjects at ages seven through eleven, there were significant differences found between recall at ages six and eleven in the present study, under conditions of both phonemic and semantic processing. It was mentioned previously that the task used by Geis and Hall was less demanding in terms of time constraints, and in terms of the order of presentation of orienting questions and stimulus words, than was the present design. It is possible that the seven year olds in Geis and Hall's study were better able to recall words for these reasons, and also because the actual number of stimuli used was only half that of the number used in the present study. Their recall results for these reasons may have been

more in line with those of the 11 year olds. In the present study, recall for the 11 year olds was based upon the results of both intentional and incidental learning groups, and since intentionality was found to exert a positive effect on 11 year old recall, their results may have been elevated beyond those of the Geis and Hall study of incidental learning. An interaction between processing level and subject age is proposed as the reason for the lack of superior recall for the 11 year olds when words had been processed to only a very shallow, physical level.

As predicted in Hypothesis 1.2, intentional learning resulted in better retention than did incidental learning for the 11 and 16 year olds under the recall conditions. It has been reported that instructions to remember have a greater effect for children of increasing age (Drucker & Hagan, 1969; Zinchenko, 1962). This received support from present recall results. The fact that recall differences for levels occurred within the older intentional groups indicates that incidental-intentional differences are most likely a function of maintenance rehearsal. Such rehearsal efforts would in turn make initial encodings more accessible. Problems with spontaneous use of such rehearsal strategies (Allik & Siegel, 1976; Ornstein, Naus & Liberty, 1976) and with the task of reconstructing an encoding per se are speculated as being the reason for a lack of effect for learning condition in the six year old group. Additionally, it is possible that the older groups have greater motivation for intentional learning tasks, in part resulting from the practise which they have had with school-related memory exercises.

Though some studies have indicated that intentionality exerts a

greater effect for shallow than deep levels of analysis (Jacoby & Goolkasian, 1973), there was no interaction between levels and learning condition in the present developmental study. Thus no support was found for Hypothesis 1.3.

In the adults tested by Jacoby and Goolkasian, it appears that semantic processing produced a type of ceiling for retention, while both physical and phonemic analysis left room for further improvement under the intentional learning condition. With the children in the present study, however, intentionality exerted an effect only for differing age groups. Within age groups its effects were not further differentiated for type of analysis. For the older children, although they were able to use elaboration and rehearsal in intentional learning conditions, there was no comparable ceiling effect for semantic analysis, and intentionality probably exerted equivalent effects for all three levels.

In line with Geis and Hall's results, there was little evidence in support of attribute preference in present recall data, and thus no support for Hypothesis 1.4. Though a preferred mode of encoding over development has been found to influence retention for visual stimuli, and words on a study list (Freund & Johnson, 1972; Hasher & Clifton, 1974; Means & Rohwer, 1976), the induced processing brought about by the orienting questions may have masked the effects of such preferred modes in the levels task. If level of analysis indeed sets an upper limit on retention (Moscovitch & Craik, 1976), and levels were systematically varied through use of specific orienting questions, then a usual preference for perceptual encoding in the youngest subjects may have been overridden by the elevated retention following induced semantic

processing.

Recognition

Hypothesis 2.1 received support in that recognition data indicated clear cut differences for the three levels of processing, in the hypothesized direction, and for all age groups. The physical-phonemic distinction, in contrast to Geis and Hall's results, was again evident, and is attributed to an improvement in design as discussed under recall results. Additionally, because the cognitive demands for recognition are less than for recall, with the provision of more cues for the reconstruction of an initial encoding (Lockhart, Craik & Jacoby, 1975), the six year olds now show differentiation between even the lower two levels of analysis. Task difficulty and cognitive level of subjects are again viewed as interactive forces contributing to final retention.

As in recall, a main effect for subject age occurred in recognition, but this effect was similarly tempered by an age x levels interaction. Hypothesis 2, like Hypothesis 1, thus receives partial support. The combined effects of cognitive sophistication in terms of increasing age, and task demands in terms of induced level of analysis, were underlined by recognition results. At a shallow, physical level of analysis both six and eleven year olds performed less well than did the 17 year olds. Following deeper phonemic processing the 11 year olds were able to recognize as many stimulus words as the 17 year olds, and following deep semantic processing subjects at all three ages were able to recognize the words equally well. Thus, even when task difficulty is reduced for the six year old subjects, and when intentionality, as discussed below, has no effect on retention of the older subjects, there remain differences

in memory due to age, in combination with task variables. Though the influence of levels of analysis on retention is a potent one, there is also a propensity of increasing age to elicit increased general memory performance. The interaction of age with levels under both response types is in keeping with the notion that levels theory can be developed in more detail only through the study of interactional tendencies of levels with other variables (Jacoby et al., 1978).

Returning to intentionality in recognition, it is apparent that any increased elaborative efforts (over and above those associated with processing depth per se) did not assist retrieval as they had in recall since there were no differences found for learning condition even for the older groups. Hypothesis 2.2 is therefore not supported. There is room for speculation that increased elaborative efforts when coupled with a recognition as opposed to a recall task provided an interfering, rather than a helpful influence. For example, more elaboration involves an increase in the number of associations for a word in memory, as well as boosting the associations of related words. These associations may assist recall by providing pathways and cues for the reconstruction of an initial encoding. However, in recognition, when powerful cues such as words are given, it may be that many associations lead to confusion, or difficulty in selecting stimulus words from several distractors which have also had their associations strengthened during processing.

With younger children it may be that the locations of related distractor words are often mistakenly accessed due to the fact that they have less mature or sophisticated cognitive abilities. The notion that young children are less able to ignore irrelevant stimuli has been discussed in the past (Brown, 1974). It also appears that the same

process may occur for older children even though their recognition scores are quantitatively greater than those of the six year olds. The 16 and 11 year olds are thought to have engaged in some manner of rehearsal or additional elaboration in the intentional condition, since the reconstruction of initial encodings (recall) was superior for them in this condition. However, this elaboration is viewed as resulting in an increase in the number of related words which are mistakenly accessed, and perhaps a resultant confusion as to the actual stimulus words, since recognition results under intentional conditions at these ages were no better than under incidental conditions. Recognition of familiar words has been discussed as being more difficult than that of unfamiliar words in adults, for the reason that related distractor words are more often accessed in the former case (Lockhart, Craik & Jacoby, 1975).

As in recall, there was no interaction between levels of analysis and learning condition for recognition, and there was thus no support for Hypothesis 2.3.

Integration of Recall-Recognition Results

According to Kintsch (1970), recall necessitates both "search" and "decision" for memory, while recognition requires only a decision component. Levels theorists maintain that both response modes require the cognitive reconstruction of an initial encoding and that recognition merely provides more cues to aid in this reconstruction. From both theoretical standpoints, the cognitive demand for recognition is less, and within the present study the six year olds were indeed less separate from the older groups when recognition was required. When words were processed to the semantic level, the cues in the recognition task may

have been adequate to provide for equivalent trace reconstruction at all three ages. This could also be stated such that it is the search component, and not decision, which differentiates developmental memory processes. Though the two descriptions may appear different only in terminology, levels of analysis provides a much clearer indication of processes involved in a "search" component by focussing on the specifics of encoding per se, and it is more compatible with recent efforts to define interactional processes in both adult and developmental memory (Chi, 1977; Jacoby, Bartz & Evans, 1978).

Moscovitch and Craik's contention that levels of analysis sets an upper limit on retention, which is molded by the retrieval environment, receives support from the present recall-recognition data. Apparently the upper limit set by semantic processing was attainable at all age levels when the retrieval environment was optimized by providing the original stimulus for recognition. Generally the younger groups became relatively less able to use even the original stimuli for retention as the level of inital encoding lessened. It may be that, due to less sophisticated perceptual and cognitive abilities, as described previously, the younger subjects are less able to differentiate actual stimulus items from distraction items when they have not been elaborated sufficiently during encoding (recognition). The fact that younger children find it more difficult to ignore competing stimuli has been mentioned previously.

Though the 11 and 17 year olds had equivalent recall for items at the deeper phonemic and semantic levels, the six year olds had significantly lower retention at all levels. At the shallow physical level even recall for the 11 year olds dropped significantly below that of

the 17 year olds. Thus it appears that cognitive development or competence has a somewhat different effect in the recall task, wherein the actual reconstruction of a memory trace is required. At age six even a deep level of initial processing does not ensure that such reconstruction will be possible. At age 11, reconstruction is in line with that of the six year olds unless initial processing has been beyond the physical level. The inter-relationship between initial processing level, cognitive level, and response mode is evident in the preceding discussion.

Conclusions-Retention Results

Recall and recognition in the present study generally increased with increases in depth of processing, thus providing further support for levels theory (Craik & Tulving, 1975; Geis & Hall, 1976).

The finding of an increase in retention with age is also a reaffirmation of past research results (Barkhatova, 1964; Nishikawa, 1975). Such results have been discussed in terms of a production, as opposed to a structural or mediational deficiency (Chi, 1977; Flavell, 1970). However, the latter authors maintain that certain strategies or mediators may require a certain level of cognitive maturity before they can be used efficiently. It follows that cognitive maturity, and the related use of verbal mediators and rehearsal efforts may indeed have provided for superior recall, especially in the present older intentional groups.

Reaction-Time

Results of the ANOVA with reaction-time data indicated main effects for both age, and levels of analysis. There is thus initial

support for hypothesis 3, of increased RT with increasing depth of analysis, and hypothesis 3.2, of decreased RT with increasing age. However these main effects are interprable only in terms of the age x levels interaction, and the age x levels x learning condition interaction.

Reaction-time (RT) has had only limited success in terms of differentiating responses under different levels of processing. Craik and Tulving (1975) found that RT could be manipulated by varying the complexity of the orienting questions, but that it was level of processing, and not decision time which determined retention. In another study with adult subjects, Shangi, Das and Mulcahy (1978) provided "qualified" support for RT as a measure of processing depth. These authors found that both phonemic and semantic responses took longer than physical responses, but did not differ from each other, and it thus appears that RT may not be a viable indicator of depth beyond the differentiation of physical and other types of processing. In present results for the 11 and 16 year olds it was similarly found that RT differentiated only physical and semantic responses. With the six year olds, RT differentiated levels to the greatest degree. Because of a lack of cognitive sophistication it may be that processing to deeper levels indeed increased the demands differentially for these children, such that RT differences occur apart from those due to age and maturational factors alone. Differences in the processing time for deeper levels of analysis are less pronounced in older subjects, unless the most extreme levels of initial encoding are compared. It is possible that the demands of the intermediate levels are not as distinctive in those whose cognitive abilities are more mature and more

flexible.

The apparent age effect in present results confirms research indicating differential "speed of information-processing" over development (Surwillo, 1977). Within the levels of processing task, younger children with less physical maturity and less sophistication in terms of cognitive abilities required more time to respond to task items.

Learning condition exerted no significant effect on RT at any age. Since there were recall improvements for the 11 and 16 year olds under intentional conditions, it appears that the operations performed by them must have been quick and efficient, with little differential effect on actual time of response. Recognition results indicated no effects for learning conidtion, and this corresponded with a lack of effect for RT. Thus the "speed of processing" difference found over age for RT does not seem sensitive to more discreet, within-age variables such as a change in learning condition.

As suggested in the rationale for reaction-time, the utility of RT seems tied more to a speed of processing dimension than to specific qualitative dimensions of processing, and therefore it is most appropriately used in combination with other dependent variables.

Simultaneous-Successive

As suggested in Hypothesis 4, factor analyses of the marker tests at all three ages resulted in loadings on three specified factors which correspond to the previously-named dimensions of simultaneous synthesis, successive synthesis, and speed (Das, Kirby & Jarman, 1975; Kirby & Das, 1978). Only one marker test had been included to index the

speed factor, thus placing the validity for 'speed' somewhat in question. Therefore speed scores were omitted from the major analyses in this section.

As indicated in Table 7, there is consistent evidence of the simultaneous and successive factors in the task loadings at ages six and eleven. At age 16 loadings are consistent for all tasks except Memory for Designs, which has its primary loading on the simultaneous factor. This finding is no doubt related to the fact that the Memory for Designs task was overly easy for the older group. Error scores were consistently very low, and many subjects at this age made no errors. It is possible that, as well as analyzing the stimuli as whole units, the 16 year olds were able to use the stimulus exposure time to break the designs down into series of the related parts, or that they attached verbal labels to the designs or parts, and the latter possibilities would involve successive processing in addition to simultaneous. The previous results are contrary to the prediction in Hypothesis 4.1, of a developmental shift in the loadings on simultaneous marker tasks.

It is of interest that, although performance increased qualitatively on the tasks for children of increasing age, the actual processes underlying performance appear to be comparable, as indexed by factor loadings. This offers support for the notion that task requirements contribute much to the cognitive analyses which are undertaken. The validity of the information-integration approach is ever strengthened by its reliability across populations of varying cultural background varying intellectual capabilities, and now of varying ages.

Molloy's (1973) study involving boys from grades one and four

also found general factors of simultaneous coding, successive coding, and speed at each age, but he suggested that the younger boys may be more ambivalent about strategies used for particular tasks, and in fact that successive processing may precede simultaneous as a general rule in all tasks. For example, the Figure Copying subtest was found to load on successive processing for grade ones, but on the expected simultaneous factor by grade four. Molloy felt that the younger subjects may see the figures as fragmented parts rather than integrated wholes, and that their performance would thus be more influenced by successive analysis. Ambivalence of the younger boys' strategy usage was also discussed in terms of the VSTM and Memory for Designs tasks. By grade four the expected loadings occurred on successive and simultaneous processing respectively, while the grade ones were found to have greater loadings on speed for both tasks, with the interpretation being that the brief stimulus exposure was not allowing them time to productively use either processing mode. It was expected on the basis of Molloy's results that six year olds in the present study would have less defined factor structures than in older subjects, and that they may in fact have a tendency to engage in successive analyses even on tasks wherein simultaneous processing would eventually become the most efficient mode. Present results, however, indicate clearly defined factors for simultaneous and successive analyses at age six, based on the results of the four marker tests.

Whereas Molloy had a third, "speed" factor in his results, present analyses excluded the Color-Naming task and specified two factors in the factor analyses at each age. Specifying two factors allowed for comparisons across age groups, and was justified since the

only age group not having two factors when no number was specified was age 16, wherein one factor resulted with the next eigenvalue being above .9. One obvious difference between the studies is thus the provision for loadings on a speed factor for the tasks in Molloy's study, and the lack of such a provision in the present study. It is possible that processing speed was represented by the successive factor on the VSTM task in our six year olds, since when Color-Naming was included in analyses VSTM was found to load with it on a speed factor. If this was the case the high loading of VSTM on the successive factor may actually represent contributions of both successive processing and speed at this age. Memory for Designs was found to load more on speed than simultaneous processing in the six year olds in Molloy's study, but in the present design even when Color-Naming was included, the Memory for Designs task loaded only on the simultaneous, and not on the speed factor. This finding is probably related to the lengthened exposure time, from 5 seconds (Molloy, 1973) to 10 seconds, which was provided in the present paradigm for the Memory for Designs task. Though this lengthening of exposure time may have created a task which was actually too simple for the 16 year olds, as discussed previously, it would appear that it provided enough time for the six year olds to effectively engage in the processing mode of their choice, and that that choice was in fact simultaneous processing. It has been suggested that speed of cognitive processing is less in younger than in older subjects, (Surwillo, 1977) and on the basis of developmental studies with simultaneous and successive synthesis it becomes obvious that this is a factor worthy of consideration. For example, tasks for young subjects must be created such that they have time to engage in

effective coding processes, to prevent the interference which results in factor loadings when speed of processing is contributing more to performance than type of processing.

It is somewhat more difficult to explain the fact that Figure-Copying had a successive loading for grade one subjects in Molloy's study, since our grade one subjects produced simultaneous factor loadings on this task. In addition, the copying task was not tied to a speed factor. The 10 figures utilized by Molloy overall comprised a less complex battery than that designed by Ashman (1978) and utilized within the present study. Although this increased complexity was intended to provide a more challenging task for 16 year old subjects, it may also have altered the task such that six year olds no longer copied figures "as fragmented series". Especially in the latter designs of the task, figures such as the three-dimensional images may have been much more difficult to copy part by part, and the six year olds may have conceptualized them as whole units, although the actual reproduction of such complex units presented a difficult task for them.

Evidence seems to favor the attribution of simultaneous and successive processing to characteristics of the task, rather than the child's age. However, as with the levels of analysis data, there must be consideration of interactions between age and type of processing, including factors such as processing speed, verbal and/or cognitive ability.

The differential contributions of simultaneous and successive processing are discussed in the following section as they relate to a memory task, in children of various ages, and thus of various levels of cognitive sophistication.

Simultaneous-Successive Processing and Levels of Analysis

Previous mention has been made of the notion that both simultaneous and successive processing would contribute to one's performance on the levels of analysis task. Basically the two types of coding or synthesis are part of a broad scheme for the classification and conceptualization of cognitive processing. The levels task, dealing with verbal stimuli and memory, in theory would fall under this general scheme. Successive processing has been implicated in verbal processing (Cohen, 1973; Das, Kirby & Jarman, 1975) and rehearsal strategies (Corballis, 1969), and simultaneous processing has been discussed in terms of verbal comprehension, and certain rehearsal strategies, by the same authors. In the following analyses an initial attempt was made to examine the factor loadings of levels of analysis recall tasks and determine whether or not the demands of the levels task can be subsumed under the coding processes, and which types of coding are influential for differing levels of recall. Factor analyses utilizing the results of both physical and semantic recall, and the four marker tests for simultaneous-successive synthesis, were undertaken as part of an exploratory analysis to determine the factor loadings for the recall tasks. Phonemic recall was excluded since it's correlations with the S-S marker tests changed affiliation depending upon whether subjects were part of an intentional or incidental learning condition, and results could not be treated as if they had come from a homogeneous group. Intercorrelations of the simultaneous-successive tasks and the recall tasks may be seen over all age levels in Tables 9, 10 and 11.

Initially the factor analyses resulted in three factors at each of ages 11 and 16, with two factors emerging at age six. However, since

the third factor's eigenvalue at age six was .953, an additional analysis specified three factors at each age, and it is this latter analysis which will provide the basis for the present discussion.

At all three ages the typical simultaneous-successive loadings occurred for the marker tasks. However, a third factor also was evident for all age groups, and since there were consistent loadings on this factor for the recall tasks, it is referred to generally as a "memory" factor (see Table 13). Though recall following verbal processing is a very specific memory task, there are indications of moderate loadings for Memory for Designs on the memory factor at ages 11 and 16. Since Auditory Serial Recall does not load on this factor, and since semantic recall is much more variable in its loading than is physical recall, it may be that this memory factor applies more to the short term retention of straight-forward, physical detail, than to the recall of material which has produced, or demanded, more meaningful analyses.

Physical recall loaded only on the memory factor at all three ages. Thus, for the very brief, and unelaborated analyses required to respond to the physical orienting questions, apparently neither simultaneous nor successive processing are significantly involved. In terms of the information-integration model put forward by Das and his colleagues (Das, 1972; Das, Kirby & Jarman, 1975), the physically processed words may have involved little more than sensory registration, and some element of planning and decision-making. Though research into a planning factor has had some recent success (Ashman, 1978), it was not included for study; the present emphasis was upon coding processes. Therefore we are able to base interpretations largely upon the influence or lack of influence of the latter processes.

The results of median-split data add clarification as to the relationship between levels of processing and simultaneous-successive analysis, and will be discussed further in the following section.

Continuing with factor-analytic results, the fact that simultaneous and successive analysis do influence performance on the levels task becomes evident when processing is at a deep, elaborated, semantic level. At age six, there is a primary loading for semantic recall on the memory factor, and a secondary loading on successive processing. At age 11 the primary loading occurs on successive processing and the secondary loading on memory, while at age 16 the primary loading returns to the memory factor, but the secondary loading is on simultaneous processing. Thus, on a task of short-term memory wherein words must be processed according to their meanings, there appears to be a transition over age in terms of the type of coding which is influential. Once again, related information concerning developmental information processing will be provided in the context of median-split data.

Though the actual recall task may be consistently loading on a separate memory factor, the subjects' cognitive development as indexed by age, and the cognitive demands of the task, once again appear to have differential, and interactive effects -- this time as to the type of coding utilized by a subject. For semantic recall the results indicate a loading on successive processing at ages six and eleven, and a transition by age 16 to a loading on simultaneous processing, providing some support for Hypothesis 4.2. Successive processing may precede simultaneous developmentally, on a task involving verbal processing, and retention. Cummins and Das (1977) suggested that the two types of coding may have different roles for children at different ages. That

is, although the relatively "pure" marker tests indicate loadings in the expected directions at all ages, tasks which are more complex, and involve both types of coding (and perhaps planning) may reveal shifts in terms of coding preferences with increasing age. Cummins and Das, for example, suggested that successive processing may be involved in basic decoding skills for reading, which would normally occur at younger ages, but that higher levels of semantic analysis may involve mainly simultaneous analysis. This hypothesis receives support from present results, in that the younger ages may be utilizing basic decoding skills which require successive processing. At older ages the children have become proficient at basic decoding, and their performance is now more dependent on higher levels of cognitive analysis such as semantic comprehension, requiring simultaneous processing. As mentioned previously, it remains to be discovered whether the "memory" factor in the present study would break down into more than one factor, perhaps largely influenced by planning and decision-making, in future studies wherein marker tasks for planning are included. It may be that most of the variance in both physical and semantic recall will be accounted for by simultaneous-successive synthesis, planning and speed, providing support for the Das model. It may also be that a factor apart from the model, and related more specifically to memory, or recall per se will remain, which would require further investigation and explanation to fit within the constraints of the model.

Median-Split Results

In addition to analyzing the factor loadings of recall with the marker tests, subjects at each age were divided as to high or low scores

for each coding factor, and these groups then served in 2 x 2 analyses of variance for physical and semantic recall. In this way it was possible to look for overall preferences for a particular mode at each age, and more importantly to examine possible interactions between simultaneous and successive processing and the resultant effects on recall.

As indicated in Table 13, there were no extreme preferences for one mode of processing at any age, since groups for high-high, high-sim, low-succ, low-sim, high-succ, and low-low, were all of relatively equal N. There were, however, some indications that one's ability or preference for a particular mode of processing was related to recall in rather specific ways.

At age six such effects were not present (See Appendix 2.1, 2.2), thus recall results were no different for those scoring high or low on simultaneous processing, etc. Though these children do score in the expected direction on actual marker tests for the S-S factors, it appears that in a more complex task one's ability for either type of coding does not contribute significantly to results at this age. Though correlational data indicated that successive processing was related in some degree to semantic recall across all six year olds, those high in successive were not found to recall significantly better than those with low factor scores, and there was no simultaneous-successive interaction.

At age 11, a simultaneous-successive interaction was found for physical recall. As presented in Figure 5, it becomes evident that 11 year olds who score high in simultaneous and low in successive tasks recall more physically processed items than any other grouping. It

appears than those high in simultaneous ability and low in successive are somehow better able also to retrieve words which they have only analyzed to very shallow levels. A possibility may be that these children tend to process words in this case as whole units (simultaneously), more so than the six year olds who use their total efforts just to find one letter and respond to the question, or the 16 year olds who choose to zero in on the letter, and apply no more effort than is necessary for the specific item. This result is difficult to interpret, since at both ages six and sixteen there were no relationships found between coding ability or preference, and physical recall. The eleven year olds have been discussed previously as being in a "transition" stage for information-processing, including the effects of depth of analysis, learning condition, etc., and it may be that somewhat spurious findings in the coding results may also be representative of such a transition.

The ANOVA results for semantic recall at age 11 indicated main effects for both simultaneous and successive processing, but whereas simultaneous factor scores correlated positively with recall, successive factor scores correlated negatively. That is, although it has been found previously that semantic recall is influenced in general by the successive factor at age 11, there is also the somewhat confusing notion that those who are better at, or prefer simultaneous processing, are also the ones who do better in semantic recall (making better use of successive processing in a specific task, even than those who prefer it in general). The transition of children from less differentiated processors, to those who have preferences and yet are unable to successfully apply them to relevant tasks, is obviously a problem area requiring further research.

At age 16, there appears to be a more "clear-cut" relationship between coding preference or ability, and application of this ability to specific tasks. The ANOVA for semantic recall at age 16 produced only a main effect for simultaneous processing, such that semantic recall is positively related to one's factor scores for simultaneous processing. This is in correspondence with the previous finding that semantic recall had a secondary loading on simultaneous processing at age 16.

For physical recall at age 16 there was no relationship found between one's factor scores for coding, and subsequent recall.

It appears that, at relatively early stages of cognitive and physical development (at least up to age 11), one's ability and/or preference for a particular type of coding does not guarantee that this type of processing will be utilized even when it is eventually found to be the most efficient for a particular task. As in the more specific levels of analysis task, both subject and environmental variables have been found to affect performance in terms of the coding processes applied to particular tasks. It is quite possible that one aspect of cognitive functioning which develops with age, is the ability, consciously or subconsciously, to actually utilize the mode of processing which is most appropriate for a task, in spite of one's own coding abilities or preferences.

Chapter VII

CONCLUSIONS

Results of the present study have indicated the potential of "process-oriented" approaches for providing insight into the actual processes affecting memory and information-processing. The utilization of a levels of processing paradigm revealed that depth of analysis, as defined by Craik and Lockhart, influences retention in children between the ages of six and sixteen years. In general it was found that the elaborative analyses performed on a stimulus increased the strength of its memory trace, across all ages. The levels approach thus provides a good base from which to examine the interactive effects of other subject and environmental variables, leading to more direct inference of further cognitive processes which affect retention. For example, present results have found, in addition to the levels effect, that intentional learning instructions can improve the retention of older subjects, and that provision of an easier retention task can improve the retention of the younger ones. By investigating factors other than, or in addition to the perceptual/cognitive analyses originally put forward by Craik and his colleagues as determinants of retention, studies such as the present one do not detract from levels of processing theory, but rather serve to refine it further. Moscovitch and Craik (1976) proposed that level, or depth of analysis, actually places an upper limit on retention, but that whether this limit is reached depends upon factors such as retrieval cues and uniqueness of encoding. Present results provide support for the notion that levels set an upper limit for "potential" memory, and add the dimensions of

learning condition, age and again response mode to those which may interact to affect this potential to some degree.

In addition to the rather specific levels theory, and its emphasis on memory, present results have provided insight as to overall cognitive processing in children from ages six through sixteen. Using the simultaneous-successive model, it was found that children at all ages are capable of both types of coding, when tasks have been selected as relatively "pure" marker tests of each type. However when tasks become more complex, the younger children will not necessarily use the type of coding which is eventually found to be most efficient for a task. It appears that subject factors such as age (and concommitant cognitive development) as well as actual task demands interact to determine cognitive "coding", in much the same manner as these factors interact with processing level to determine recall. On the basis of present results, one would not conclude a change in the overall use of one or another coding mode as children grow older, since marker-test results indicate that even at age six children were able to use both coding modes. However, there are indications that the early development of tasks such as the recall of semantically processed items, and reading (Cummins & Das, 1977) require decoding activities which may in turn be associated with successive processing. For this reason younger children may engage in relatively more successive coding in their day to day activities than do older children. The older children have mastered skills like basic decoding and use simultaneous coding for tasks wherein it is the most efficient mode.

Present data must be further refined in terms of discovering more specific relationships between extraneous variables and depth of

processing for memory, and between extraneous variables and task demands per se for type of coding used. However, the results to this point indicate trends which may have very practical importance in terms of educational programming.

When children of any age are presented with material which they must retain in memory, they will have the highest probability of success when that material has been processed semantically, that is when it is cognitively analyzed in terms of its meaning. Historical, linguistic or even arithmetical information thus should be presented in a context which is relevant to a child's interests, culture, and environment, for the most efficient "remembering" to occur. In the case of older children, over about 10 years of age, instructions as to which material is to be remembered will allow children to utilize their own strategies such as rehearsal, grouping, etc. In children younger than this the task variables such as relevancy and interest or attentional value remain of major importance, since strategy-usage (and thus effects of learning condition) appear much weaker in these children. To assure an adequate degree of success, and enhance motivation in the younger group, educators may have to lessen demands in terms of response mode. Present results indicate that recall was generally less over all conditions for the six year olds, but that the less demanding recognition task, with deep semantic encoding, was performed just as well by the six year olds as the 16 year olds.

There are some indications that young children may typically engage in successive coding for verbal memory and reading, and that for this reason presentation of such material would be done most efficiently using successive or sequential methods. Along these lines, older

children (with a transition period perhaps about the time of Piaget's "formal operations") are better able to conceptualize material as whole units, and are able to benefit from demands for concept formation and abstract thinking.

In general, the aims of this study, in terms of furthering our theoretical knowledge about memory and information-processing, through developmental data, and interactions between task and subject variables, have seemingly been met.

Chapter VIII

LIMITATIONS OF THE PRESENT STUDY AND IMPLICATIONS FOR FUTURE RESEARCH

Recognition was used in addition to recall in the present study when it became apparent that the six year olds may have been experiencing a floor effect for recall. As a result of this "after the fact" decision, there were only 32 of the 50 subjects at each age who were given the recognition task, and all of these were given the task following an attempt at free recall of the words. Since it is impossible to completely separate these results, in terms of the fact that recall efforts may have served to bolster the subsequent recognition of items, it would have been preferable to have separate groups of subjects under the recall and recognition conditions. This may indeed provide an interesting addition in studies attempting to replicate present results. In addition, the use of only 32 subjects with the recognition response mode prevented their inclusion in factor analytic studies with simultaneous-successive marker tests, and subsequent studies may find such analyses of interest. Comparison of loadings of the recall and recognition response modes may provide process-oriented information, rather than the traditional, theoretical and descriptive notions, concerning their points of similarity and difference.

The levels of anlaysis data have indicated strong support for the levels theory in general, and the latter seems to provide a logical core from which to extend further studies of memory. In addition, since there appears to be a transition in terms of the effects of learning condition, and depth of processing per se around age 11, it is important that more detailed information be obtained for children at ages around

this transition point. By administering the levels task to children, for example, from ages seven to fourteen, one could gain further information as to the age at which most children begin acting upon instructions to learn, through the use of rehearsal strategies, etc., which in turn results in more efficient memory performance. One could also estimate with more certainty the interactional effects between depth of analysis, and cognitive development or sophistication, with information as to the age at which children are able to recall even shallowly processed items, the age at which only deeply processed or elaborated items can be retrieved using the recall mode, and the age at which items must be deeply processed and complimented by a less demanding, recognition response mode before successful retention can occur.

Thus, although levels theory has been, and is yet, open to criticism (Baddeley, 1978; Eysenck, 1978; Naus, 1978) the interactions between variables such as levels, age, and retrieval mode provide valuable information regarding the process of retention. Eysenck himself discusses the levels approach as being a "welcome shift" from an emphasis on external events to an emphasis on internal, cognitive events. Within his critical review he suggests at one point that the use of two or more retention measures would provide one method of further testing the levels effect in any one study. Present results, utilizing both recall and recognition, provide evidence for a levels effect in both retrieval environments and, as discussed above, lead the way to more detailed study of memory functioning. In spite of current theoretical limitations, the levels of processing approach to memory must not be discarded hastily or prematurely.

Analyses of the simultaneous-successive marker test scores and the

recall data indicated the potential utility of including planning tasks, and perhaps speed tasks, in subsequent batteries to be analyzed with memory data. Such inclusions become important when one is attempting to examine the factor loadings for an extraneous task such as recall, within the information-integration model. Since planning is a major factor within the central processor, it is necessary to allow for a specific "planning" factor with which some of the variance for a task such as recall can align itself. Only in this manner will it be possible to obtain a comprehensive measure of the degree to which a task such as recall can be "subsumed" under the general information-integration model. Findings may be overwhelmingly in support of the latter model, or they may indeed indicate certain factors which are not easily explained within the context of the model. In either case our knowledge of human information-processing would be strengthened.

One specific alteration which would be suggested in terms of the simultaneous-successive tasks involves the scoring of the Memory for Designs task. To alleviate the problem of ceiling effects (zero errors) which occurred for the present 16 year old group, the MfD task may be scored more rigorously for errors, and a score of correct responses, rather than errors, may be utilized in analyses.

As discussed previously, there are indications from present results that certain transitions occur in the use of coding processes, between ages six and sixteen. It appears that, although children as young as age six are capable of both types of processing, they are influenced mainly by task demands, and not their ability at one mode or another or a preference for one mode, in terms of the actual type of coding which occurs for a task. However, the mode utilized may not

be that which is eventually found most efficient for a task, and it appears that in many cases successive analyses will occur for tasks which, at higher developmental levels, will be taken over by simultaneous. By age 11 there is slightly more evidence that children are beginning to use the modes which are eventually found to be most efficient for tasks. An 11 year old may be very good at one of the modes, as indicated by results on the relatively pure marker tests, but there is no guarantee that he will utilize that mode even when it is the one used effectively by older children. By age 16, children seem able to effectively use their abilities or preferences for the two types of coding, since they do choose the coding which is most efficient for a task, and those with high scores on the pure measures of this coding are also found to use it most efficiently on the respective tasks.

As a result of these hypothesized transitions in the efficient use of coding processes, it also becomes necessary to study the information-integration model at levels of development closer to one another than those of the present study. As with the results of levels of processing it will then become possible to make finer discriminations as to the time at which children develop particular coding strengths or preferences, and the subsequent effects that these have on the type of coding utilized for a variety of tasks.

REFERENCES

Allik, J.P., & Siegel, A.W. The use of cumulative rehearsal strategy: A developmental study. Journal of Experimental Child Psychology, 1976, 21(2), 316-327.

Ashcroft, M.H., & Kellas, G. Organization in normal and retarded children: Temporal aspects of storage and retrieval. Journal of Experimental Psychology, 1974, 103, 502-508.

Ashman, A.F. The relationship between planning and simultaneous and successive synthesis. Unpublished doctoral dissertation, University of Alberta, 1978.

Atkinson, R.C., & Shiffrin, R.M. Human memory: A proposed system and its control processes. In K.W. Spence and J.T. Spence (Eds.), The psychology of learning and motivation. Vol. 2. New York: Academic Press, 1968, 89-195.

Bach, M.J. & Underwood, B.J. Developmental changes in memory attributes. Journal of Educational Psychology, 1970, 61, 292-296.

Baddeley, A.D. The psychology of memory. New York: Basic Books, 1976.

Baddeley, A.D. The trouble with levels: A reexamination of Craik and Lockhart's framework for memory research. Psychological Review, 1978, Vol. 85, No. 3, 139-152.

Baldwin, A.L. Theories of child development. New York: John Wiley & Sons, Inc., 1967.

Barkhatova, S.G. The relation between the speed and accuracy of recall. Communication 1. Izv. Akad. Pedag. Nauk RSFSR, 1964, No. 129, in Cole, M. and Maltzman, I. A handbook of contemporary Soviet psychology, New York: Basic Books, Inc. 1969.

Battig, W.F. & Montague, W.E. Category norms for verbal items in 56 categories: A replication and extension of the Connecticut category norms. Journal of Experimental Psychology, 1969, 80, 6, Pt. 2.

Baumeister, A.A., & Kellas, G. Reaction time and mental retardation. In N.R. Ellis (Ed.), International review of mental retardation. Vol. 3. New York: Academic Press, 1968, 163-193.

Bee, H. The developing child, New York: Harper & Row Publishers, Inc., 1975.

Beery, K.E. Developmental Test of Visual Motor Integration. Chicago, Ill.: Follett Educational Corporation, 1967.

Belmont, J.M., & Butterfield, E.C. The relation of short-term memory to development and intelligence. In L.P. Lipsitt & H.W. Reese (Eds.), Advances in child development and behavior. Vol. 4. New York: Academic Press, 1969, 30-83.

Binet, A. L'etude experimentale de l'intelligence. Paris: Schleicher, 1903.

Blishen, B.R. A socio-economic index for occupations in Canada. In B.R. Blishen, F.E. Jones, K.D. Naegele and J. Porter (Eds.), Canadian society: sociological perspectives. 3rd edition. New York: Macmillan, 1966, 741-753.

Bower, G.H. A multicomponent theory of the memory trace. In K.W. Spence and J.T. Spence (Eds.). The psychology of learning and motivation. (Vol. 1). New York: Academic Press, 1967.

Bower, G. (Ed.) Human memory: Basic Processes. New York: Academic Press, 1977.

Broadbent, D.E. Perception and communication. London: Pergamon Press, 1958.

Brown, A.L. The role of strategic behavior in retardate memory. In Ellis, N.R. (Ed.) International Review of Research in Mental Retardation Vol. 7. New York: Academic Press, 1974.

Brown, J. (Ed.), Recognition and recall. London: Wiley, 1975.

Burt, C. The structure of the mind. British Journal of Educational Psychology, 1949, 19, 100-111, 170-199.

Carroll, J.B. Psychometric tests as cognitive tasks: A new "structure of intellect". In L. Resnick (Ed.) The nature of intelligence. Hillsdale, N.J.: L. Erlbaum, 1976.

Chi, M. Age differences in memory span. Journal of Experimental Child Psychology, 1977, 23, 266-281.

Cohen, G. Hempispheric differences in serial versus parallel processing Journal of Experimental Psychology, 1973, 97, 349-356.

Cole, M., Frankel, F., and Sharp, D. Development of free recall learning in children. Developmental Psychology, 1971, 4, No. 2 109-123.

Conrad, R. Acoustic confusions in immediate memory. British Journal of Psychology, 1964, 55, 75-84.

Corballis, M.C. Patterns of rehearsal in immediate memory. British Journal of Psychology, 1969, 60, 41-50.

Craik, F.I.M. A "levels of analysis" view of memory. In P. Pliner, Lakrames, and T. Alloway (Eds.) Communication and affect: Language and thought. New York: Academic Press, 1973.

Craik, F.I.M. Depth of processing in recall and recognition. In S. Dornic & P.M.A. Rabbit (Eds.), Attention and Performance, Vol. VI. 1977.

Craik, F.I.M., & Jacoby, L.L. A process view of short-term retention. In F. Restle, R.M. Shiffrin, N.J. Castellan, H.R. Lindman, and D. Pisoni (Eds.) Cognitive theory: Volume 1. New York: Erlbaum, 1975.

Craik, F.I.M., & Tulving, E. Depth of processing & the retention of words in episodic memory. Journal of Experimental Psychology: General 1975, 104, 268-294.

Craik, F.I.M., & Lockhart, R.S. Levels of processing: A framework for memory research. Journal of Verbal Learning and Verbal Behavior, 1972, 11, 671-684.

Cramer, P. Changes from visual to verbal memory organization as a function of age. Journal of Experimental Child Psychology, 1976, 22(1), 50-57.

Cummins, J. and Das, J.P. Cognitive processing and reading difficulties: A framework for research. The Alberta Journal of Educational Research, 1977, Vol. XXIII, No. 4, 245-256.

Das, J.P. Verbal conditioning and behavior. Oxford: Pergamon Press, 1969.

Das, J.P. Patterns of cognitive ability in nonretarded and retarded children. American Journal of Mental Deficiency, 1972, 77, 6-12.

Das, J.P. Structure of cognitive abilities: Evidence for simultaneous and successive processing. Journal of Educational Psychology, 1973, 65, 103-108.

Das, J.P., Kirby, J., & Jarman, R.F. Simultaneous and successive synthesis: An alternative model for cognitive abilities. Psychological Bulletin, 1975, 82, 87-103.

Das, J.P., & Molloy, G.N. Varieties of simultaneous and successive processing in children. Journal of Educational Psychology, 1975, 67, 213-220.

Drucker, J.F. & Hagen, J.W. Developmental trends in the processing of task relevant and task irrelevant information. Child Development, 1969, 40, 371-382.

Estes, W.K. Learning theory and intelligence. American Psychologist, 1974, 29, 740-749.

Eysenck, M.W. Levels of processing: A critique. British Journal of Psychology, 1978, 69, 157-169.

Eysenck, M.W. Levels of processing: A reply to Lockhart and Craik. British Journal of Psychology, 1978, 69, 177-178.

Felzen, E. & Anisfeld, M. Semantic and phonetic relations in the false recognition of words by third- and sixth-grade children. Developmental Psychology, 1970, 3, 163-168.

Fisher, R.P. & Craik, F.I.M. Interaction between encoding and retrieval operations in cued recall. Journal of Experimental Psychology: Human Learning and Memory, 1977, Vol. 3, No. 6, 701-711.

Flavell, J.H. Developmental studies of mediated memory. In H.W. Reese & L.P. Lipsitt (Eds.), Advances in child development and behavior. Vol. 5. New York: Academic Press, 1970, 181-211.

Frank, H. & Rabinovitch, M.S. Auditory short-term memory: Developmental changes in rehearsal. Child Development, 1974, 45, 397-407.

Frost, N. Encoding and retrieval in visual memory tasks. Journal of Experimental Psychology, 1972, 95, 317-326.

Freund, J. & Johnson, J. Changes in memory attribute dominance as a function of age. Journal of Educational Psychology, 1972, 63, 386-389.

Fruchter, B. Introduction to factor analysis. Princeton, New Jersey: D. Van Nostrand Company, Inc., 1954.

Geis, M.F. & Hall, D.M. Encoding and incidental memory in children. Journal of Experimental Child Psychology, 1976, 22, 58-66.

Graham, F.K. & Kendall, B.S. Memory for Designs Test: revised general manual. Perceptual and Motor Skills, Monograph Supplement 2-7, 1960, 11, 147-188.

Hagen, J.W. & Huntsman, N.J. Selective attention in mental retardates. Developmental Psychology, 1971, 5, 151-160.

Hahn, W.W. Attention and heart rate: A critical appraisal of the hypothesis of Lacey and Lacey. Psychological Bulletin, 1973, 79, 59-70.

Harman, H.H. Modern factor analysis. Chicago: The University of Chicago Press, 1960.

Hasher, L. & Clifton, D. A developmental study of attribute encoding in free recall. Journal of Experimental Child Psychology, 1974, 17, 332-346.

Hunt, E. & Lansman, M. Cognitive theory applied to individual differences. In W.K. Estes (Ed.), Handbook of learning and cognitive processes. Vol. 1, Hillsdale, N.J.: Lawrence Erlbaum Associates, 1975.

Ilg, F.L. & Ames, L.B. School Readiness: Behavior Tests used at the Gesell Institute. New York: Harper and Row, 1964.

Jacoby, L.L., Bartz, W.H. & Evans, J.D. A functional approach to levels of processing. Journal of Experimental Psychology: Human Learning and Memory, 1978, 4, No. 4, 331-346.

Jacoby, L.L. & Goolkasian, P. Semantic versus acoustic coding: retention and conditions of organization. Journal of Verbal Learning and Verbal Behavior, 1973, 12, 324-333.

Jarman, R.F. Level I and level II abilities: Some theoretical reinterpretations. British Journal of Psychology, 1978, 69, 257-269.

Jenkins, J.J. Remember that old theory of memory? Well, forget it! American Psychologist, 1974, 29, 785-795.

Jenkins, J.J. Can we have a theory of meaningful memory? In P.L. Solso (Ed.) Theories in cognitive psychology. The Loyola Symposium, Maryland. Lawrence Erlbaum, 1974.

Jennings, J.R. Cardiac reactions and different developmental levels of cognitive functioning. Psychophysiology, 1971, Vol. 8, No. 4, 433-450.

Jensen, A.R. A theory of primary and secondary familial mental retardation. In N.R. Ellis (Ed.), International review of research in mental retardation. Vol. 4. New York: Academic Press, 1970, 33-105.

Kintsch, W. Models for free recall and recognition. In D.A. Norman (Ed.), Models of human memory. New York: Academic Press, 1970.

Kirby, J.R. & Das, J.P. Information processing and human abilities. Journal of Educational Psychology, 1978, Vol. 70, No. 1, 58-66.

Kogan, N. Educational implications of cognitive styles. In G.S. Lesser (Ed.), Psychology and educational practice. Scott, Forseman, and Co., 1971, 242-292.

Kucera, H., & Francis, W.N. Computational analysis of present day American English. Providence, R.I.: Brown University Press, 1967.

Laurence, M.W. Age differences in performance and subjective organization in free-recall learning of pictorial material. Canadian Journal of Psychology, 1966, 20, 388-399.

Lawson, M.J. An examination of the levels of processing approach to memory. Unpublished doctoral dissertation, University of Alberta, 1976.

Lockhart, R. Comments regarding multiple response phenoména in long inter-stimulus, internal conditioning. Psychophysiology, 1966, 3, 108-114.

Lockhart, R.S. & Craik, F.I.M. Levels of processing: A reply to Eysenck. British Journal of Psychology, 1978, 69, 171-175.

Lockhart, R.S., Craik, F.I.M., & Jacoby, L.L. Depth of processing in recognition and recall: Some aspects of a general memory system. In J. Brown (Ed.), Recognition and recall. London: Wiley, 1975.

Luria, A.R. Higher cortical functions in man. New York: Basic Books, 1966. (a)

Luria, A.R. Human brian and psychological processes. New York: Harper & Row, 1966. (b)

MacFarlane-Smith, I. Spatial ability: Its educational and social significance. London: University of London Press, 1964.

Maccoby, E.E. Selective auditory attention in children. In L.P. Lippsitt & C.C. Spiker (Eds.) Advances in child development and behavior. Vol. 3 New York, Academic Press, 1967.

Mazuryk, G., & Lockhart, R.S. Negative recency and levels of processing in free recall. Canadian Journal of Psychology, 1974, 28, 114-123.

Means, B.M. & Rohwer, W.D. Jr. Attribute preference in memory development. Journal of Experimental Psychology, 1976, Vol. 12, No. 5, 411-417.

Meyers, K.A. & Obrist, P.A. Psychophysiological correlates of attention in children. Psychophysiology, 1973, 10, 210.

Molloy, G.N. Age, socioeconomic status and patterns of cognitive ability. Unpublished doctoral dissertation, University of Alberta, 1973.

Moscovitch, M. & Craik, F.I.M. Depth of processing, retrieval cues, and uniqueness of encoding as factors in recall. Journal of Verbal Learning and Verbal Behavior, 1976, 15, 447-458.

Mulaik, S.A. The foundations of factor analysis. New York: McGraw-Hill Book Company, 1972.

Mussen, P.H. & Conger, J.J. Child development and personality. New York: Harper & Brothers, 1956.

Naus, M.J. Developmental implications of the levels of processing memory framework. Paper presented, Levels of Processing Symposium, American Psychological Association, Toronto, Canada, 1978.

Naus, M.J., Ornstein, P.A. & Aivano, S. Developmental changes in memory: The effects of processing time and rehearsal instructions. Journal of Experimental Child Psychology, 1977, 23, 237-251.

Nishikawa, K. Analysis of structural change of intelligence and genetic relations: A 9 year follow up study. Psychologia: An International Journal of Psychology in the Orient, 1975, 18(1), 1-14.

Ornstein, P.A., Naus, M.J. & Liberty, C. Rehearsal and organizational processes in children's memory. Child Development, 1976, 46(4), 818-830.

Paivio, A., Yuille, J.C. & Madigan, S. Concreteness, imagery, and meaningfulness values for 925 nouns. Journal of Experimental Psychology Monograph, 1968, 76, (1, Pt. 2).

Piaget, J. On the development of memory and identity. Barre, Mass.: Clark University Press and Barre Publishers, 1968.

Reese, H.W. Models of memory development. Human development, 1976, 19, 291-303.

Safer, D.J. & Allen, R.P. Hyperactivity in Children. Baltimore: University Park Press, 1976.

Shangi, L.M., Das, J.P. & Mulcahy, R. Heart rate, recall, and reaction-time measures of levels of processing. Perceptual and Motor Skills, 1978, 46, 187-198.

Spearman, C. The abilities of man. London: Macmillan, 1927.

Stroop, J.R. Studies of interference in serial verbal reactions. Journal of Experimental Psychology, 1935, 18, 643-661.

Surwillo, W.W. Human reaction time and period of the EEG in relation to development. Psychophysiology, 1971, 8, 468-482.

Surwillo, W.W. Developmental changes in the speed of information processing. The Journal of Psychology, 1977, 96, 97-102.

Treisman, A. & Tuxworth, J. Immediate and delayed recall of sentences after perceptual processing at different levels. Journal of Verbal Learning and Verbal Behavior, 1974, 13, 38-44.

Tulving, E. Cue-dependent forgetting. American Scientist, 1974, 62, 74-82.

Tulving, E. & Bower, G.H. The logic of memory representations. In G.H. Bower (Ed.), The psychology of learning and motivation. Vol. 8. New York: Academic, 1974.

Tursky, B., & Teiffer, E. Development of strategies for recall and recognition. Journal of Experimental Psychology, 1976, 12, No. 5, 406-410.

Underwood, B.J. Attributes of memory. Psychological Review, 1969, 76, 559-573.

Underwood, B.J. Are we overloading memory? In A.W. Melton & E. Martin (Eds.), Coding processes in human memory, Washington, D.C.: Winston, 1972.

Underwood, B.J., & Freund, J.S. Word frequency, and short-term recognition memory. American Journal of Psychology, 1970, 83, 343-351.

Van der Veur, B.W. Imagery rating of 1000 frequently used words. Journal of Educational Psychology, 1975, 67, 44-56.

Vernon, P.E. Intelligence and cultural environment. London: Methuen, 1969.

Walsh, D.A., & Jenkins, J.J. Effects of orienting tasks on free recall in incidental learning: 'difficulty', 'effort', and 'process' explanations. Journal of Verbal Learning and Verbal Behavior, 1973, 12, 481-488.

Waugh, N.C., & Norman, D.A. Primary memory. Psychological Review, 1965, 72, 89-104.

Wepman, J.M. Auditory perception and imperception. In Cruickshank, W. & Hallahan, D.P. (Eds.) Perceptual and learning disabilities in children: Research and theory, Vol. 2. New York: Syracuse University Press, 1975.

Zeaman, D., & House, B.J. The role of attention in retardate discrimination learning. In N.R. Ellis (Ed.), Handbook of Mental Deficiency. New York: McGraw-Hill, 1963, 159-233.

Zinchenko, P.I. Involuntary remembering. Moscow: Izd. Akad. Pedag. Nauk, 1962.

APPENDIX 1

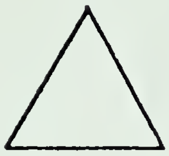
APPENDIX 1.1

Levels of Analysis Task

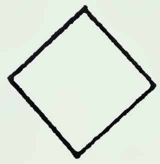
1.	carrot	Does this word rhyme with hunter?
2.	balloon	Does this word start with a "t"?
3.	corn	Does this word end with a "p"?
4.	bed	Does this word rhyme with shed?
5.	foot	Does this word mean part of your body?
6.	ball	Does this word mean something to play with?
7.	dress	Does this word rhyme with star?
8.	shirt	Does this word mean something to play with?
9.	chair	Does this word mean something to ride in?
10.	leg	Does this word start with "l"?
11.	train	Does this word end with an "h"?
12.	bus	Does this word rhyme with fuss?
13.	nose	Does this word start with a "b"?
14.	clock	Does this word mean something people wear?
15.	lettuce	Does this word rhyme with door?
16.	hat	Does this word mean a type of vegetable?
17.	desk	Does this word rhyme with book?
18.	car	Does this word start with a "c"?
19.	bicycle	Does this word mean something for a house?
20.	kite	Does this word end with an "e"?
21.	boat	Does this word rhyme with goat?
22.	eye	Does this word start with an "l"?
23.	doll	Does this word end with a "g"?
24.	shoe	Does this word start with an "s"?
25.	coat	Does this word rhyme with moat?
26.	table	Does this word rhyme with stable?
27.	truck	Does this word mean something to ride in?
28.	potato	Does this word mean a type of vegetable?
29.	spinach	Does this word rhyme with sky?
30.	arm	Does this word mean part of your body?

Memory-for-Design Test (MFD)

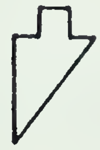
1



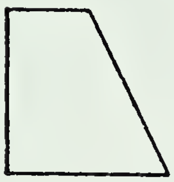
2



3



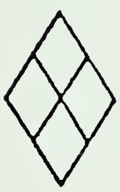
4



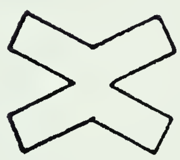
5

6

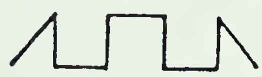
7



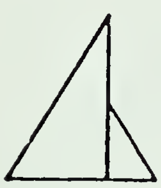
8



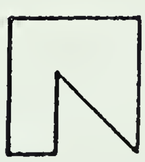
9



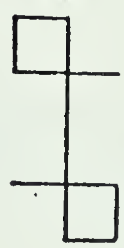
10



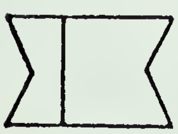
11



12



13

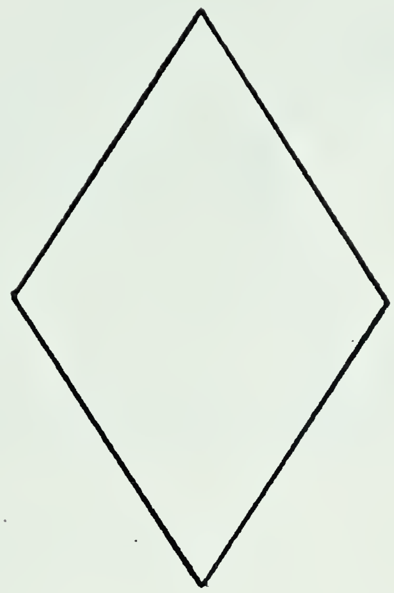


14

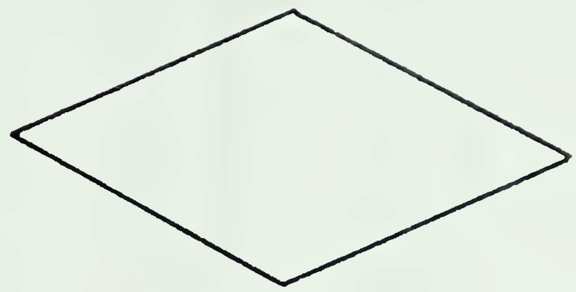
15

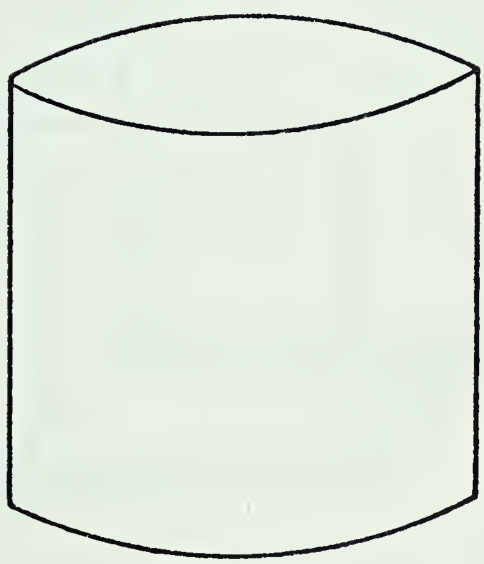
APPENDIX I.3

Figure Copying

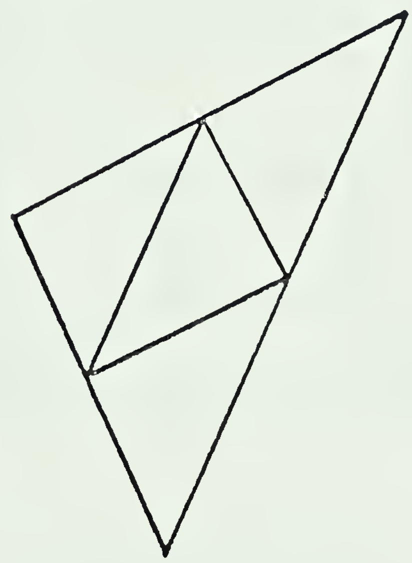


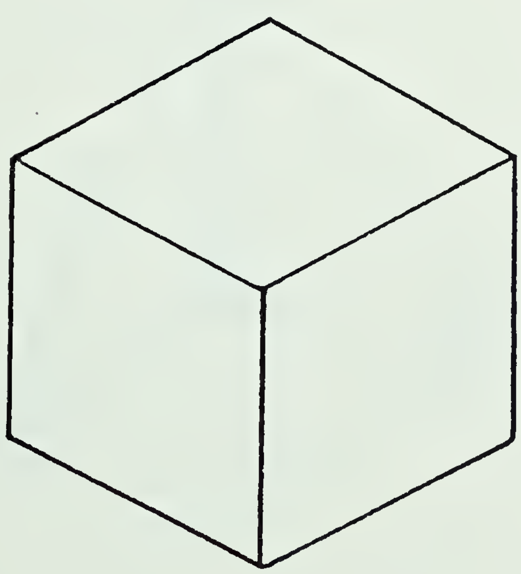
2.



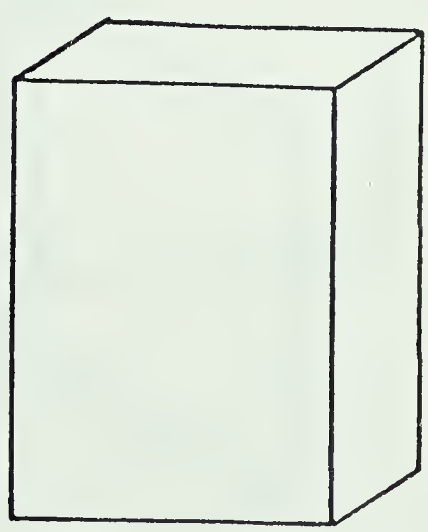


4.

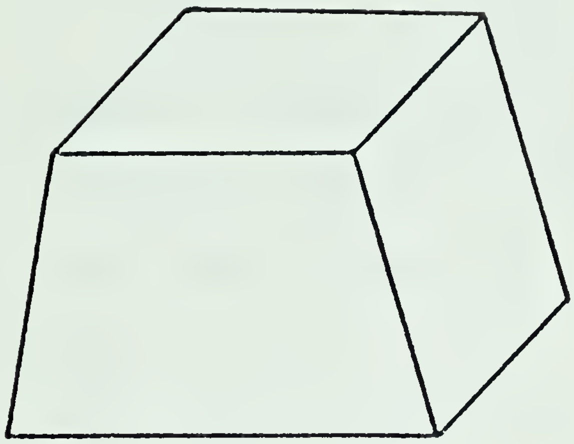




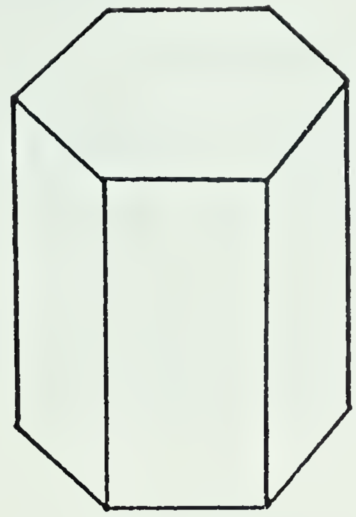
6.



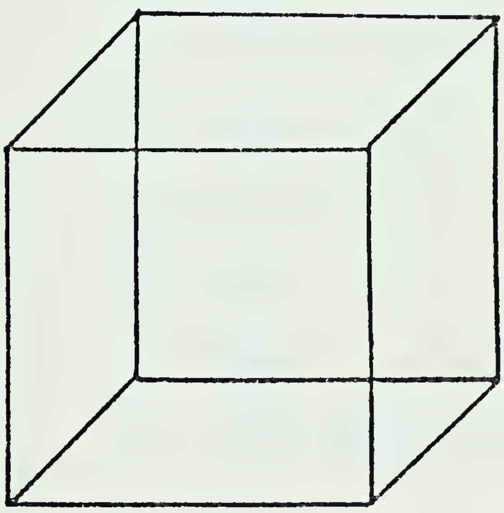
7.



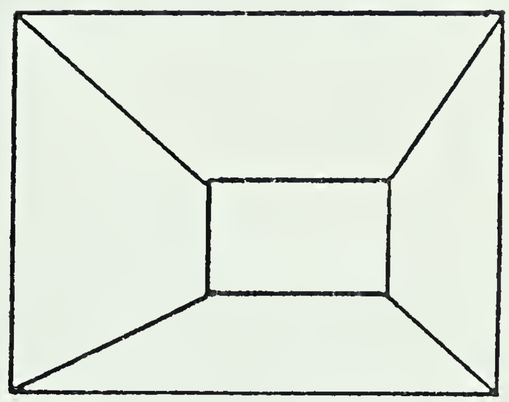
8.



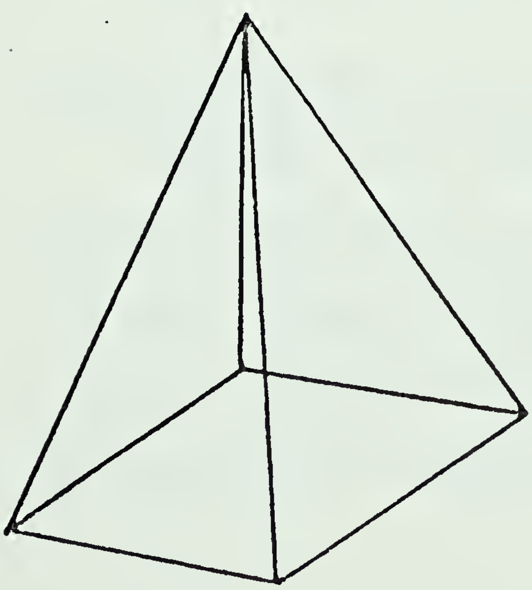
9.



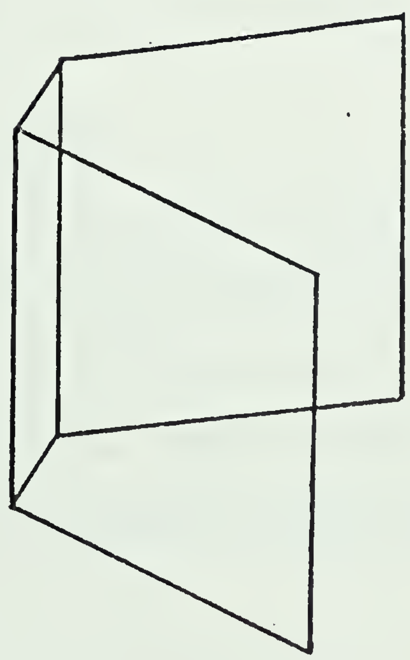
10.



11.



12.



Guidelines for Administering and Scoring the Figure Copying Test

The subject is required to make an exact, free-hand copy of twelve shapes: a vertical diamond; a horizontal diamond; a cylinder; tilted triangles; a cuboid; an enclosed box; a trapezoid; an octahedron; a necker cube; a tapered box; a pyramid; and a stylized open book. Drawings are scored according to accuracy of shape rather than absolute size. The following principles apply:

For all Drawings

1. The drawing must generally maintain the proper perspective
2. Drawings where applicable should be symmetrical
3. Angles should not be rounded
4. Figures should not be rotated
5. Angles should be equal, when applicable
6. Slight bowing or irregularity of lines is permitted
7. Lines should meet approximately, but small gaps or extensions are acceptable
8. When two attempts are made, the worst is scored

Scoring Principles for Individual Figures

Scoring of each figure involves some limited flexibility. In general, some principles are considered more important than others and are more stringently enforced. In the following table of standards, criteria are given in order of importance. Where the same numbers are given for two criteria, they are considered equally important.

1. Vertical Diamond

    1. No 'kite' shapes

    1. Horizontal opposing corners

    2. Four good corners

    3. Only slight 'dog-ears' allowed

    4. Both acute angles must be 60% or less

2. Horizontal Diamond

    1. No obvious 'kites'

    1. Opposing corners

    2. Four good corners

    2. Horizontal axis between 170° and 190°

    3. Both acute angles 60° or less

3. Cylinder

    1. Diameters should be approximately equal to the height

    2. Diameters of the base and top should be approximately equal

    2. The base and the top lines should be curved

4. Tilted Triangles

    1. Two triangles

    2. Right outer side sloped 100° or more

    3. Two corners of inner triangle clearly touch near medians of outer triangle, and the third must be close

    3. Left outer angle approximately 90°

5. Cuboid

1. Proper perspective must be perserved as in the specimen

2. There should be three approximately equal diamonds

3. All lines should be approximately equal (i.e. lengths, widths and heights)

6. Enclosed Box

1. Proper perspective must be maintained as in the specimen

1. Figure must be almost half as high as it is wide

2. Acute angles of parallelogram should be between 30° and 45°

7. Trapezoid

1. Proper perspective should be preserved as in the specimen

2. Parallelograms should have angles of approximately 45°

8. Octahedron

1. Hexagon should have approximately equal sides

2. Vertical rectangle should be bounded by two, near equal parallelograms

3. Left and right extreme angles of the hexagon should be near 90°

9. Necker Cube

1. Correct number of parts

1. Correct orientation

1. No evidence of confusion

10. Tapered Box

1. No confusion or distortion

2. Inner form clearly shifted to the right and down

3. Outer form a parallelogram

3. Inner form a horizontal rectangle

11. Pyramid

1. Figure is balanced around the vertical

1. No confusion or distortion

2. Base of figure is a diamond

2. All triangles are near isosles

12. Stylized Open Book

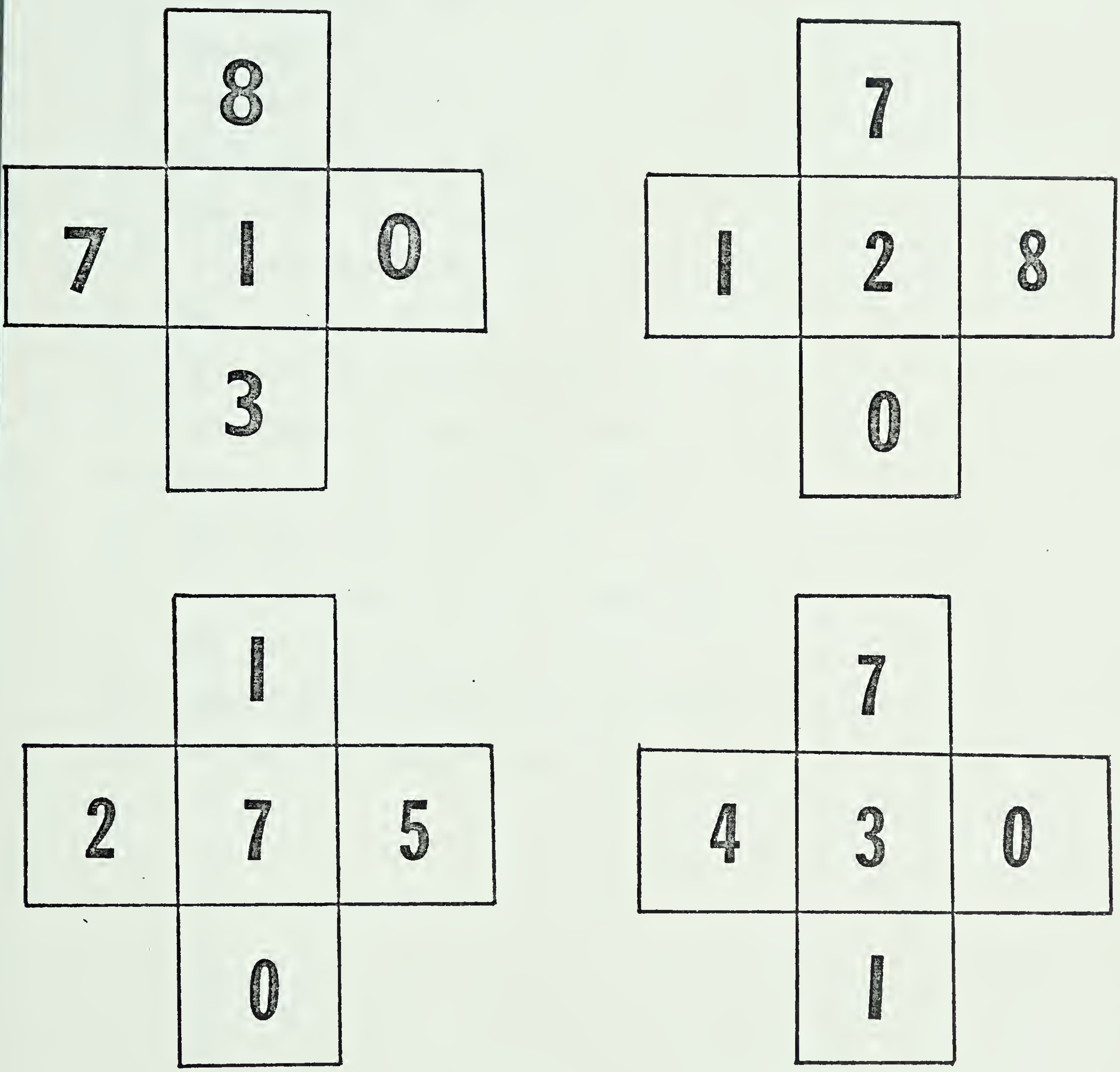
1. Two, mirror-image parallelograms with the acute angles near 75°

1. No confusion or distortion

2. Thin parallelogram should have acute angles between 30° and 45°

APPENDIX 1.4

Visual Short-Term Memory
(Sample Grids)



APPENDIX 1.5

Auditory Serial Recall

1. tall, long, big, huge
2. high, tall, fat, big
3. day, cow, wall, bar
4. key, few, hot, book
5. book, bar, wall, hot, mat
6. wide, tall, large, huge, broad
7. long, big, great, wide, fat
8. few, pen, hot, wall, bar
9. key, hot, cow, pen, wall, book
10. wide, large, big, high, tall, vast
11. long, big, fat, great, large, huge
12 pen, wall, book, key, cow, hot
13. high, fat, huge, wide, long, large, broad
14. day, key, cow, bar, wall, few, hot
15. great, high, tall, long, big, broad, fat
16. cow, day, bar, wall, few, mat, key

APPENDIX 2

APPENDIX 2.1

ANOVA and Cell Means for Physical Recall at Age 6.7
Involving Median-Split Data for
Simultaneous and Successive Factor Scores

ANOVA Table

Source	df	MS	F
B_1 (Successive)	1/46	.5633	0.50
B_2 (Simultaneous)	1/46	.1633	0.15
$B_1 \times B_2$	1/46	.5633	0.50
Error	46	.1118	

Cell Means

		Simultaneous High	Simultaneous Low
Successive	High	.600	.500
	Low	.600	.933

APPENDIX 2.2

ANOVA and Cell Means for Semantic Recall At Age 6.7
Involving Median-Split Data for
Simultaneous and Successive Factor Scores

ANOVA Table

Source	df	MS	F
B_1 (Successive)	1/46	.4800	0.29
B_2 (Simultaneous)	1/46	.00003	0.00
$B_1 \times B_2$	1/46	.0533	0.03
Error	46	1.666	

Cell Means

Successive	Simultaneous: High	Simultaneous: Low
High	1.733	1.800
Low	1.600	1.533

APPENDIX 2.3

ANOVA and Cell Means for Physical Recall at Age 11.4 Involving Median-Split Data for Simultaneous and Successive Factor Scores

ANOVA Table

Source	df	MS	F
B_1 (Successive)	1/46	.6343	3.43
B_2 (Simultaneous)	1/46	.1543	0.83
$B_1 \times B_2$	1/46	.7669	4.14*
Error	46	.1852	

*$p < .05$

Cell Means

Successive	Simultaneous: High	Simultaneous: Low
High	.636	1.071
Low	2.143	1.000

APPENDIX 2.4

ANOVA and Cell Means for Semantic Recall at Age 11.4
Involving Median-Split Data for
Simultaneous and Successive Factor Scores

ANOVA Table

Source	df	MS	F
B_1 (Successive)	1/46	18.75	5.74*
B_2 (Simultaneous)	1/46	13.63	4.17*
$B_1 \times B_2$	1/46	.8308	0.25
Error		3.269	

*p<.05

Cell Means

Successive	High Successive	Low Successive
High	4.455	3.143
Low	5.429	4.636

APPENDIX 2.5

ANOVA and Cell Means for Physical Recall at Age 16.9
Involving Median-Split Data for
Simultaneous and Successive Factor Scores

ANOVA Table

Source	df	MS	F
B_1 (Successive)	1/46	.1201	0.04
B_2 (Simultaneous)	1/46	.1201	0.04
$B_1 \times B_2$	1/46	1.919	0.69
Error	46	2.787	

Cell Means

Successive	Simultaneous High	Simultaneous Low
High	1.700	1.400
Low	1.200	1.700

APPENDIX 2.6

ANOVA and Cell Means for Semantic Recall at Age 16.9 Involving Median-Split Data for Simultaneous and Successive Factor Scores

ANOVA Table

Source	df	MS	F
B_1 (Successive)	1/46	5.333	2.76
B_2 (Simultaneous)	1/46	9.013	4.66*
$B_1 \times B_2$	1/46	.8530	0.44
Error	46	0.933	

*$p < .05$

Cell Means

Successive	High Simultaneous	Low Simultaneous
High	5.000	3.867
Low	5.400	4.800